

Product Overview | April 2015

Specifying flexible conduit systems for the rail infrastructure industry

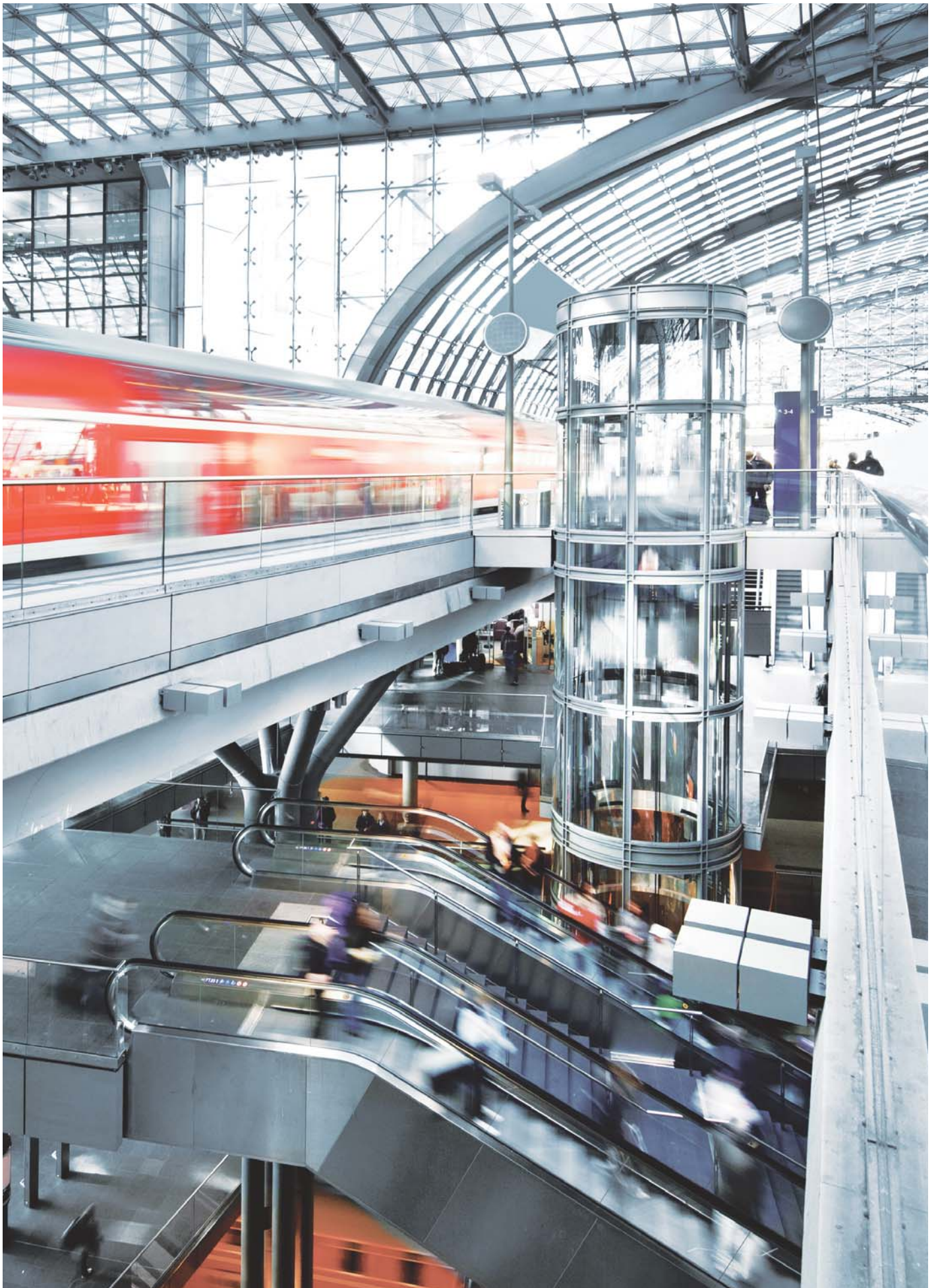
Adaptaflex

Power and productivity
for a better world™ **ABB**



Specifying flexible conduit systems for the rail infrastructure industry

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Specifying flexible conduit systems

Company overview and industry standards

Company overview and industry standards

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ABB in the rail industry

Innovative solutions for sustainable mobility

1

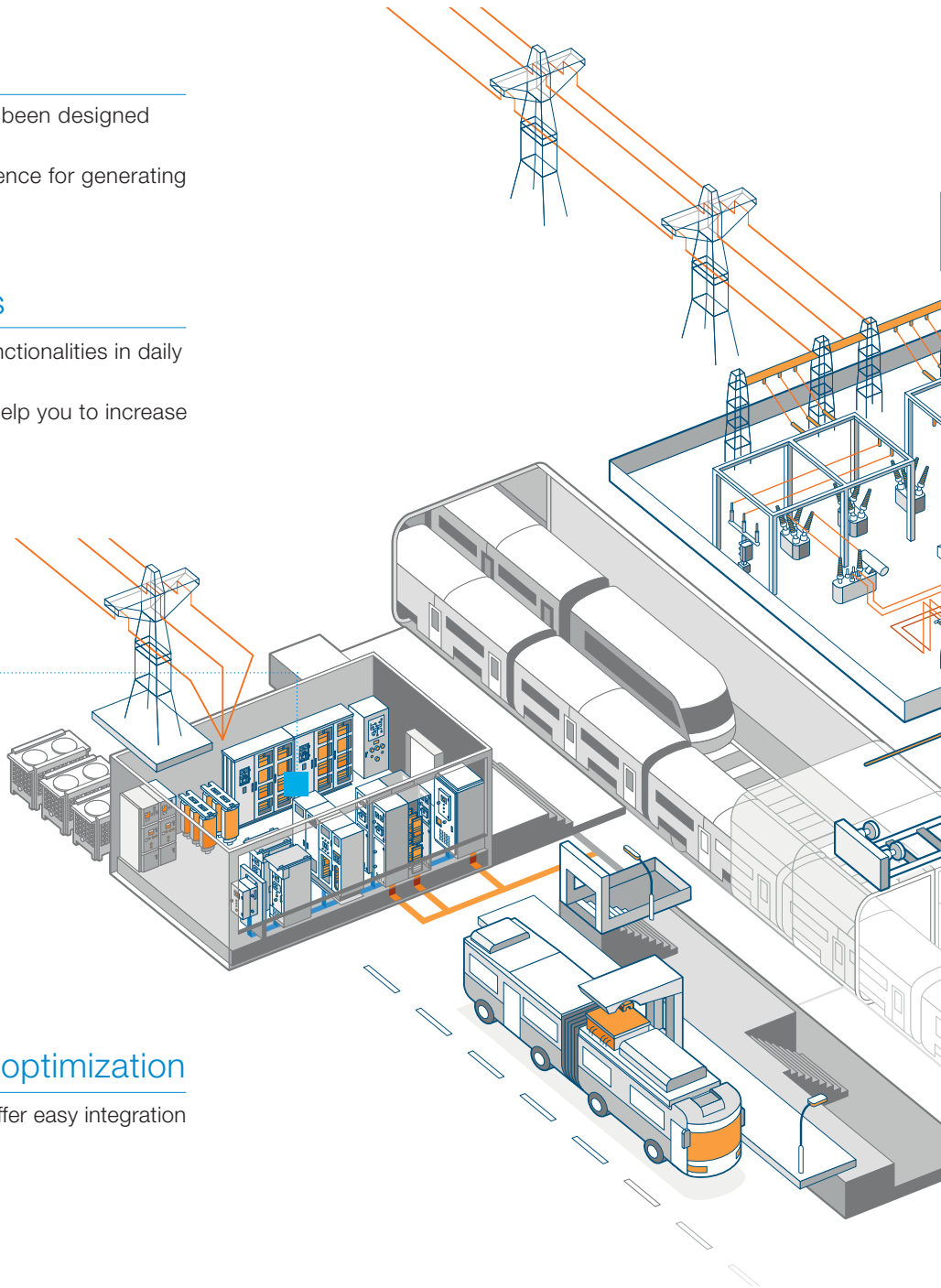
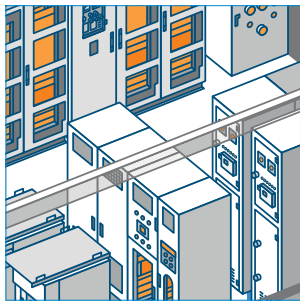
ABB is a world leading supplier of innovative technologies for the rail industry with a comprehensive range of solutions for rolling stock and infrastructure. We help to keep the world moving with new sustainable approaches that enable customers to use energy effectively, creating a low carbon transportation industry that operates with maximum efficiency and reliability.

Energy saving

Our innovative products and solutions have been designed to increase efficiency in all installations. Reliable systems are managed with competence for generating productivity and energy saving.

Ensure continuity of services

ABB products have proven their excellent functionalities in daily use under the toughest conditions. Our high performance products allow us to help you to increase the reliability of your equipment.



Easy integration and system optimization

ABB compact and modular product ranges offer easy integration into all types of switchgear and automation.

ABB supports the high levels of expectations for a safe means of transport

Our knowledge of more than 30 years in the railway industry allows us to offer a wide range of products and solutions for rail applications, which meet the latest international standards and customer's requirements.

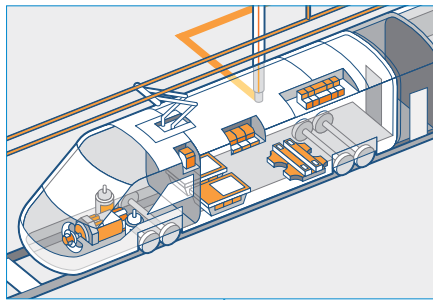
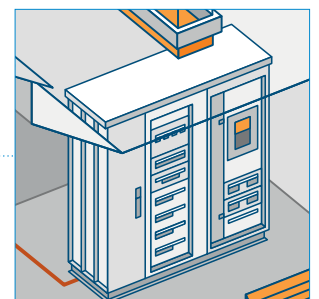
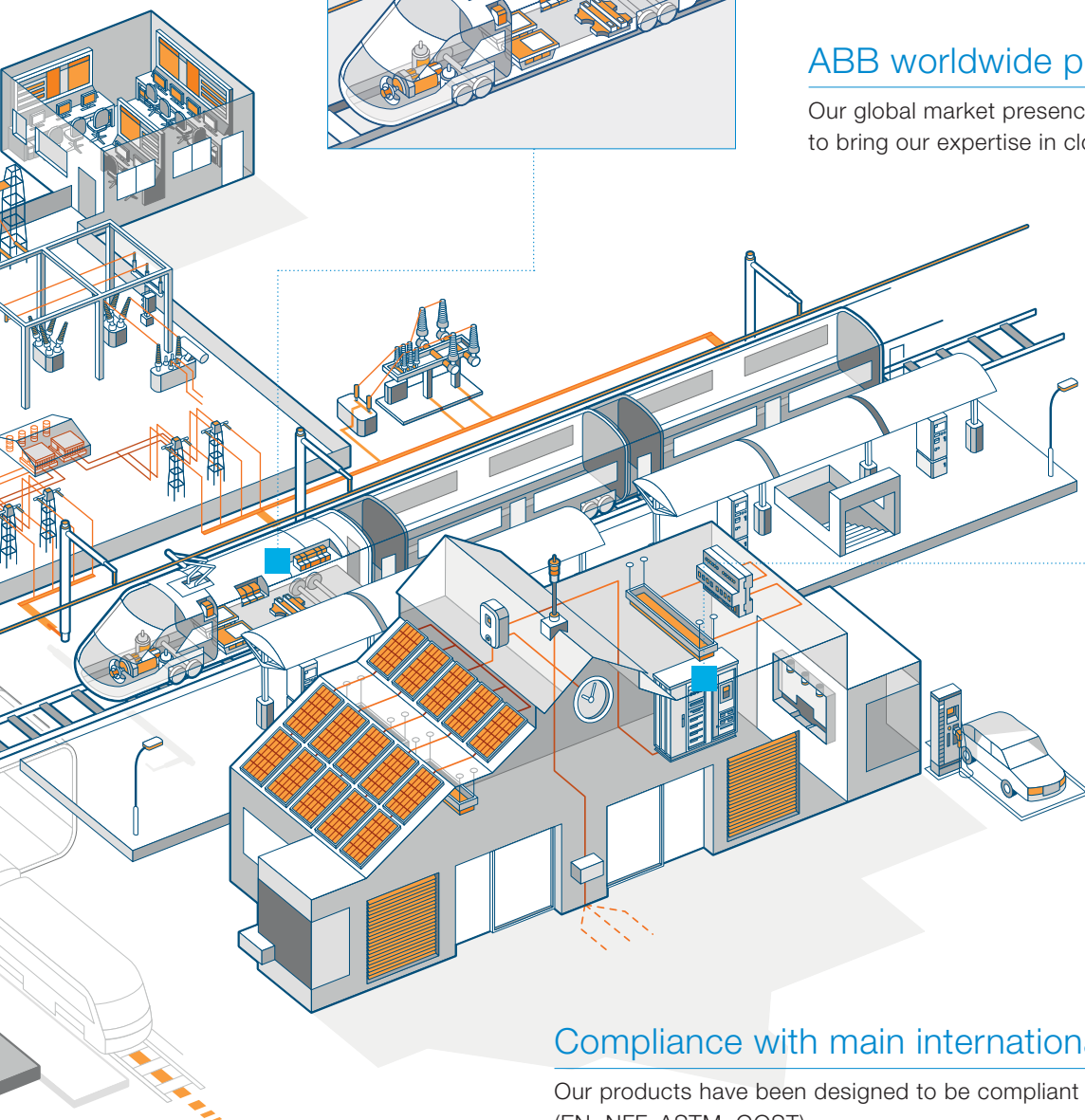


ABB worldwide presence and support

Our global market presence in over 100 countries allows us to bring our expertise in close proximity to our customers.



Compliance with main international railway standards

Our products have been designed to be compliant with main international standards (EN, NFF, ASTM, GOST).

ABB factories are IRIS certified. This is showing our commitment to optimize all processes and to participate in the development for a sustainable mobility.



Introduction

Company overview

1



Adaptaflex is a market leading flexible conduit system brand in Europe and as part of ABB has subsidiaries and distribution partners throughout the world. Flexible conduit systems from Adaptaflex are used to protect critical power and data cabling in a wide range of markets, combining innovative design with dedicated manufacturing capability.

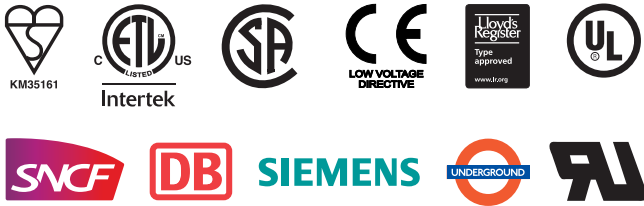


Adaptaflex is able to offer customers the widest selection of cable protection systems with a full range of metallic and non-metallic flexible conduit systems. This includes the most advanced conduit system available on the market today. 'Adaptalok ATS' is an evolutionary, one-piece moulded fitting providing ultimate performance in the most demanding wet or dry conditions.

'Adaptalok ATS' conduit fittings are easy to fit, simple to remove and considerably reduce installation times. With the conduit seal and face washer as an integral part of the fitting, the required IP ratings can be achieved by a simple 'push - twist - pull' installation process which requires no tools. A single Adaptalok ATS fitting will cover all of the IP standard performance levels simplifying product selection.

Introduction

Industry standards



Industry standards

All of our products are tested and certified by independent third party agencies to exceed international and industry standards so that you can have every confidence when specifying our products. This is in addition to our regular internal testing procedures.

As one of the world leading flexible conduit system manufacturers, Adaptaflex has gained many International approvals. With active participation on leading technical committees looking at International Standards, we are able to use our experience and knowledge to ensure safety and quality levels are maintained now and in the future.



BS EN ISO14001 Environmental standard

Controlling the impact of manufacturing activities on the environment is a major challenge. All Adaptaflex products comply with the requirements of EU directive 2011/65/EU on the restriction of the use of certain hazardous substances (RoHS). This forms part of the legislation on waste management and is aligned with Waste Electrical and Electronic Equipment (WEEE).

Our rail sector experience

For more than 40 years we have worked with the foremost manufacturers and suppliers of public transportation systems throughout the world. Leading corporations such as Alstom Transport, Bombardier Transportation, Siemens Transportation, CAF, Ansaldo Breda, Talgo, Hitachi Rail, Kawasaki, Metra Chicago, Nippon and Tangshan Rail are just a few of the companies that have worked with us for specific design solutions. We understand not just the Standards that you need to work to, but also the Industry issues that you face, including your customer service delivery expectations to get the right products to the right place on time.

Our flexible conduit systems need to perform in a wide variety of environments from high temperature to freezing sub-zero conditions. Withstanding constant vibrations and water ingress, offering corrosion resistance with availability in halogen free, low smoke and low toxicity materials to meet one of the most technically demanding markets in the world. Whether your project involves rolling stock, infrastructure, signalling, surveillance or data and information systems, our experience and product range, can provide the answer to specifying the correct flexible conduit system for your application.

Technical / Design support

As an experienced supplier of cable protection systems for the Rail and Underground industries, we know the importance of the correct specification of product especially where public safety is concerned. We have in-depth knowledge and understanding of the International requirements placed on products and materials.

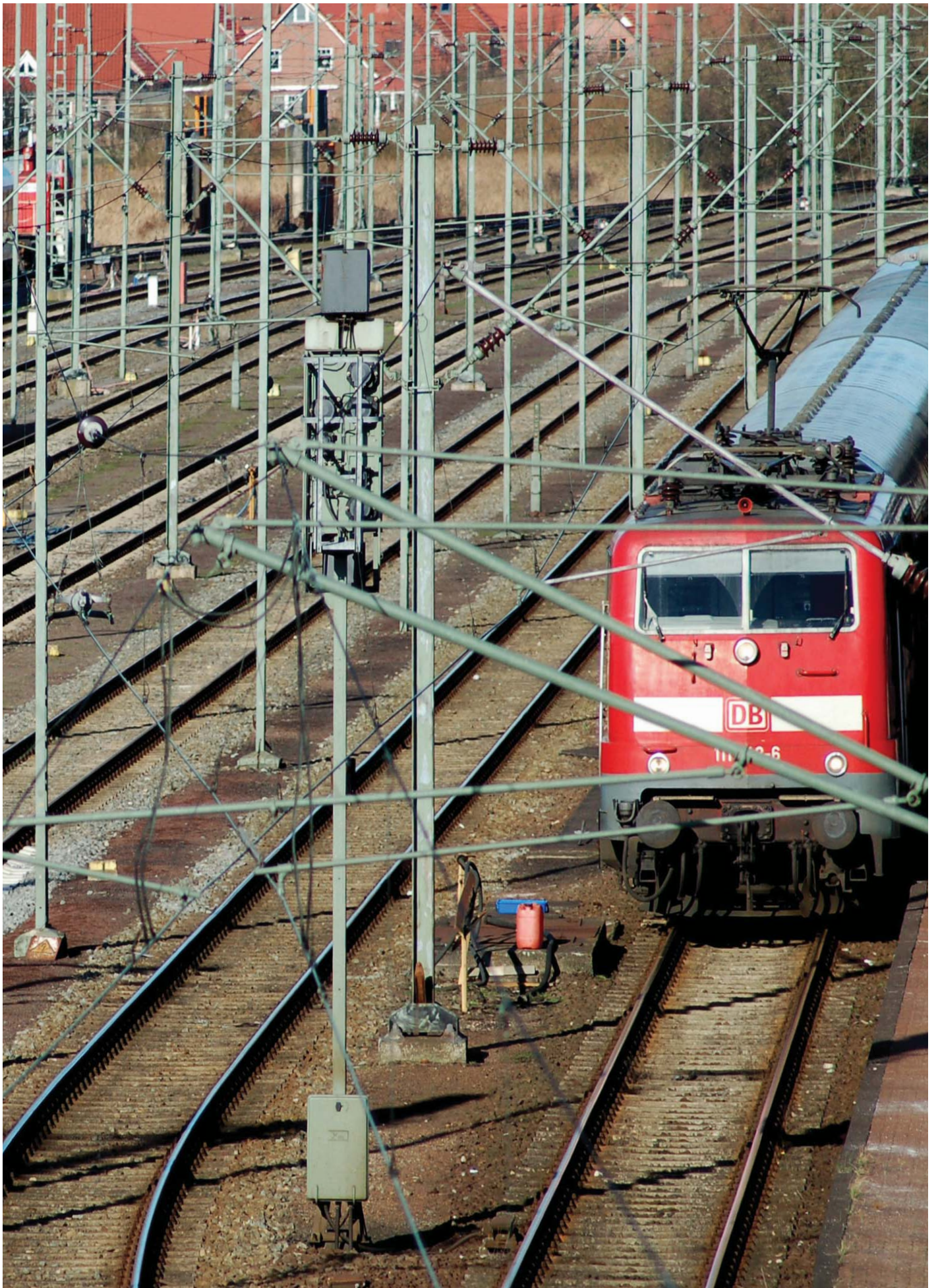
Our experience and knowledge, has helped us develop unique and cutting edge products to meet the rigorous demands required.

Technical Services

- Fire, product and performance documentation
- Drawing interchange between engineering functions
- Customised product development to meet specific projects / applications
- Bespoke testing, international approved testing
- Third party approvals
- Technical assistance throughout specification and design
- Widest range of products offering the correct cable management product for the application
- Design, iterations to completion, including provision for future maintenance and upgrades.

We offer advice on any specific application, e-mail the technical team at cmg.conduitsystems@tnb.com. For sales enquiries email sales@adaptaflex.com or telephone +44 (0) 1675 468 222.

This guide offers general application advice for conduit applications within the Rail Industry. It is given in good faith and based on our knowledge and experience of previous applications of our conduit systems. However this is generic advice and we recommend specific applications are assessed to ensure that the selected product meets the desired specification.



Specifying flexible conduit systems

Applications and product recommendations

Applications and product recommendations

Protecting critical power and data cabling	2/2
High speed and express trains	2/2
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Light rail and tram	2/3
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Applications and product recommendations

Protecting critical power and data cabling

2



The primary function of a conduit system is to protect critical cable and connections from damage caused through all external influences - mechanical, electrical and environmental. In certain areas the conduit system will also need to comply with the standards and regulations applied - particularly in regard to reaction to fire.

Use of flexible conduit systems on rolling stock

There are four major locomotive types each of which have their individual requirements:

- High Speed and Express
- Commuter and Regional
- Light Rail and Tram
- Metro

High speed and express trains

An expanding sector providing fast, efficient, and comfortable rail links over large distances. High speed trains are beginning to compete with air travel as an efficient means of transportation for long distances. Infrastructure investments made to boost train use for long distance travel has seen a global increase in this sector.

Flexible conduit systems need to provide:

- Vibration-proof connections
- High system connection strength
- High ingress protection
- High impact strength even at low temperatures
- Long-term reversed-bending resistance
- High fire protection (flammability and smoke generation)
- Good weather and UV resistance

Adaptaflex product recommendation

- PR type conduit
- PK type conduit
- PRSS type conduit
- PKSS type conduit
- PRTC type conduit
- PF type conduit
- PFSS type conduit
- PFTC type conduit

Applications and product recommendations

Flexible conduit systems on rolling stock



2

Commuter & regional, intercity railways

Electric (EMU's) and diesel (DMU's) options provide commuters with safe and reliable rail links. Spacious compartments, separate zones for working, including Internet access, comfortable seats and modern light systems all designed to make journeys an enjoyable experience.

Flexible conduit systems need to provide:

- A safe, reliable system that is easy and quick to install
- Vibration-proof connections
- High system connection strength
- High ingress protection
- High impact strength
- High compression strength
- Good chemical resistance
- Fire protection
- Good weather and UV resistance

Adaptaflex product recommendation

- PR type conduit
- PF type conduit
- LFH-SP type conduit
- LFH-SPL type conduit
- SPLHCB type conduit
- SS type conduit
- SB type conduit
- **NEW** SPL-EF type conduit

Light rail and tram

Light rail and tram systems are being installed to beat urban congestion and improve city accessibility. New urban transport systems are designed to offer sustainable public transport systems that are safe, comfortable and accessible. These vehicles have a minimum of installed equipment.

Flexible conduit systems need to provide:

- Durability and be light weight
- High fire protection
- A safe, reliable system that is easy and quick to install
- Good ingress protection
- Good weather and UV resistance

Adaptaflex product recommendation

- PA type conduit
- PR type conduit
- PF type conduit
- **NEW** SPL-EF type conduit

Applications and product recommendations

Conduit systems for specific train areas

2



Metro and underground systems

In 2015, more than 500 cities passed the 1 million-inhabitant mark. Metros are one of the proposed solutions to expanding heavy urban transit demands, with more cities investing in high-capacity urban transport networks. These are generally lightweight with minimally equipped vehicles for short city journeys.

Flexible conduit systems need to provide:

- Vibration-proof connections
- A high system connection strength
- High levels of ingress protection
- High impact strength even at low temperatures
- High compression strength
- Long-term reversed-bending resistance
- High chemical resistance, weathering and UV resistance

Adaptaflex product recommendation

- PF heavyweight type conduit
- PK type conduit
- PR type conduit
- PKSS type conduit
- PKTC type conduit
- PRSS type conduit
- SSB type conduit
- LFH-SP type conduit
- LFH-SPL type conduit
- **NEW** SPL-EF type conduit

Conduit systems for specific train areas

There are three specific train areas to consider:

Bogies

Bogies are widely considered the single, most crucial component of a train, it is the vital area where wheels meet the rails. In this tough environment, due to their high mechanical strength and resistance to ballast damage, stainless steel braided systems are widely used. This environment places high demands on the conduit system in terms of their fatigue endurance, impact and flexing performance.

Flexible conduit systems need to provide:

- Vibration-proof connections
- A high system connection strength
- High levels of ingress protection
- High impact strength even at low temperatures
- High compression strength
- Long-term reversed-bending resistance
- High chemical resistance, weathering and UV resistance

Adaptaflex product recommendation

- PF heavyweight type conduit
- PKSS type conduit
- PRSS type conduit
- SSB type conduit
- SPLHCB type conduit
- LFH-SPL type conduit
- **NEW** SPL-EF type conduit

Applications and product recommendations

Conduit systems for specific train areas



Carriage exteriors

The primary consideration for rolling stock exteriors are harsh environmental conditions, supplementary to this are good LFH properties. Conduit systems need to have a strong combination of mechanical properties with high and low temperature options. The impact and ballast damage that can be caused on high speed trains require conduit systems to be very tough and durable. Stainless steel overbraiding offers enhanced performance for all conduit systems.

Adaptaflex product recommendation

- PA heavyweight type conduit
- PF type conduit
- PFCH type conduit
- PFSS type conduit
- PFCSSS type conduit
- PKSS type conduit
- PKTC type conduit
- SSB type conduit
- PFFS type conduit
- SSBGS type conduit
- SPLHCB type conduit
- **NEW** SPL-EF type conduit

Carriage interiors

The most critical criteria for conduit products used on the interiors of rolling stock is the material performance and its reaction to fire. Adaptaflex offer conduit systems that have very low smoke and toxicity coupled with very low flame spread properties. With the increasing amount of ancillary equipment being installed in carriages, there is also a need to ensure that sensitive systems are not compromised by EMI and conduit systems can greatly assist with systems protection.

Adaptaflex product recommendation

- PR type conduit
- PF type conduit
- PK type conduit
- STC type conduit type
- LFH-SP type conduit
- LFH-SPL type conduit
- **NEW** SPL-EF type conduit

Applications and product recommendations

Use of flexible conduit systems in infrastructure

Use of flexible conduit systems in infrastructure

Stations, car parks and control centres

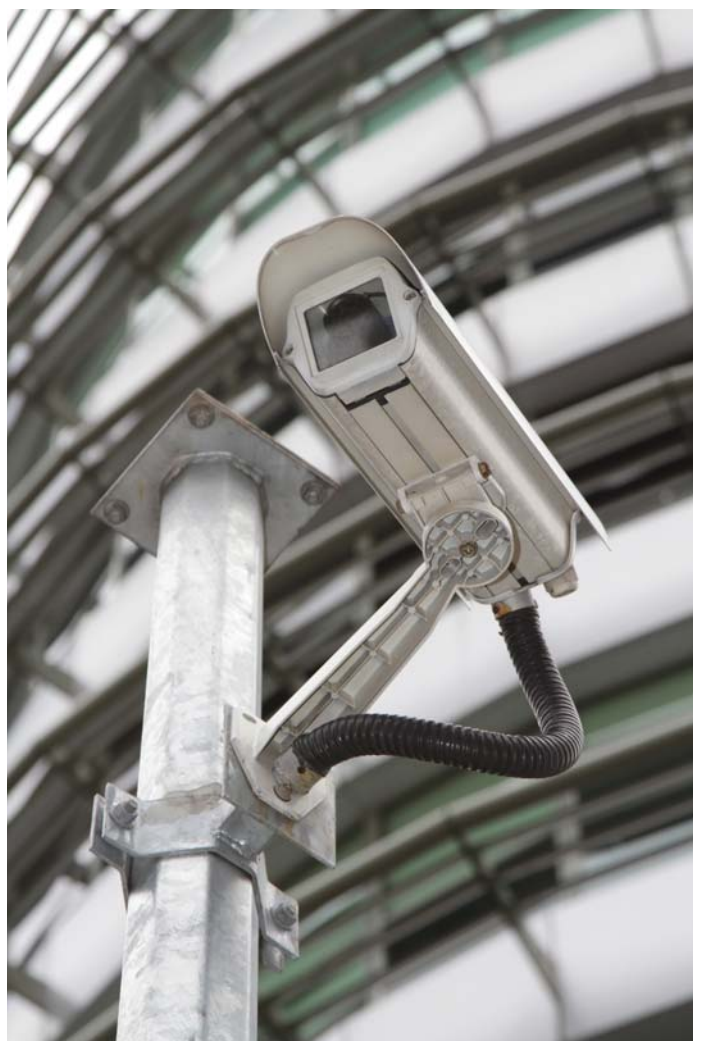
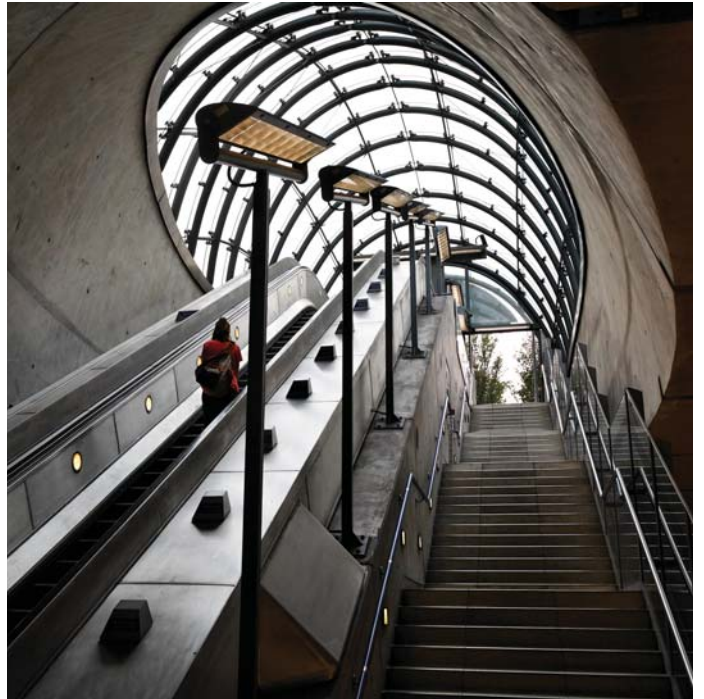
Passenger information systems, lighting, public address systems, CCTV, ticketing and barriers all need to be reliable and protected from accidental damage, vandalism and the environment. Where conduits are visible they need to be aesthetically pleasing and fit in with the overall architectural design of the surroundings. Stations are public areas and have specific fire hazard requirements that must be complied with. In underground and metro stations the fire requirements are even more demanding.

Application areas for flexible conduit systems:

- Barriers
- Lighting
- Heating
- CCTV
- Display boards
- Public address systems
- Ticketing equipment
- Public information systems
- Escalators / Moving Walkways
- Train location
- Passenger information displays
- Public address amplifiers
- Lifts

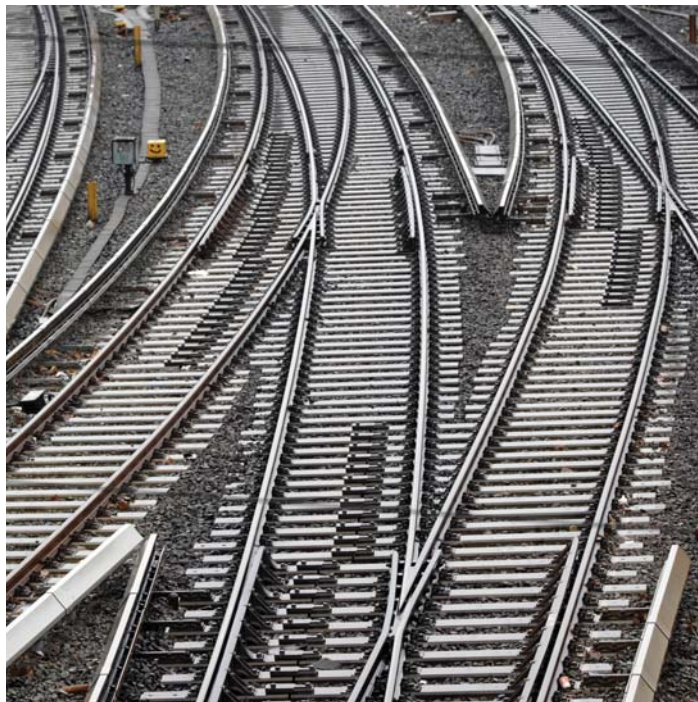
Adaptaflex product recommendation

- PA heavyweight type conduit
- PF standard weight conduit
- PR standard weight type conduit
- PK lightweight type conduit
- PRSS conduit
- PKSS conduit
- SSBGS type conduit
- LFH-SP type conduit
- LFH-SPL type conduit
- STC type conduit
- SB type conduit
- SS type conduit
- **NEW** SPL-EF type conduit



Applications and product recommendations

Use of flexible conduit systems in infrastructure



Trackside

Point switching, lighting, signalling, braking systems and warning systems all need to be extremely reliable. To ensure reliability, these systems need additional protection from impact (ballast) damage, harsh environmental conditions as well as accidental damage. In exposed areas protection from vandalism can also be needed.

Application areas for flexible conduit systems:

- Signals & Braking systems
- Warning systems
- CCTV camera to monitor switching
- Radio base stations and amplifiers
- Main power distribution & Overhead powerlines
- Signal boxes & Point switching

Adaptaflex product recommendation

- PF heavyweight type conduit
- PFTC type conduit
- PFSS type conduit
- PK type conduit
- PKTC lightweight type conduit
- PKSS lightweight type conduit
- PRTC standard weight type conduit
- PRSS standard weight type conduit
- STC type conduit
- SSBGS type conduit
- SPLHCB type conduit
- **NEW** SPL-EF type conduit

Tunnels

A fire in any tunnel is extremely dangerous and the primary concern is one of fire safety. A conduit system must be of the highest specification in order to protect vital control and monitoring equipment from impact (ballast) damage, the harsh environmental conditions, accidental damage and vandalism.

Application areas for flexible conduit systems:

- Warning systems
- Tunnel ventilation
- Fire main valves
- Tunnel lighting
- CCTV camera to monitor tunnel
- Fire detection
- Gas detection
- Sump pumps
- HVAC
- Tunnel fans and dampers

Adaptaflex product recommendation

- PK type conduit
- PKSS type conduit
- PKTC type conduit
- LFH-SP type conduit
- LFH-SPL type conduit
- LFH-SPSS type conduit
- **NEW** SPL-EF type conduit



Specifying flexible conduit systems

Reducing fire hazards

Reducing fire hazards

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NFPA130 Federal Railroad Administration (North American Standard)	3/11

Reducing fire hazards

Hazardous categories

3



Limited Fire Hazard (LFH), Low Smoke and Fume (LSF) and Low Smoke Zero Halogen (LSOH) are terms given to products that are considered non hazardous in the event of a fire. LFH, LSF, and LSOH terms are derived from cable industry Standards.

To be classified as LFH Products must have low levels of **ALL** of the following toxic elements:

- Carbon Monoxide Carbon Dioxide, Phosphor, Sulphur Oxides of Nitrogen, Halogens (Chlorine, Bromine, Fluorine)
- Must generate Low Smoke & Fumes
- Have high ignition requirements such as a high oxygen index or temperature index and Low flame propagation and be self-extinguishing.

This criteria gives people **TIME** - **TIME** to escape and **TIME** to deal with the fire.

Performance Aspects

Difficult to ignite and self-extinguishing

Inflammable materials prevent a fire from taking hold. Self extinguishing materials contain a fire and prevent spreading.

Low toxicity and zero halogen

Products when consumed by fire emit toxic fumes. Eliminating the toxic chemicals in materials used to manufacture these products prevent toxic fumes attacking people and equipment. One of the most notorious groups of chemicals is halogens (Fluorine, Chlorine and Bromine) which, when burnt give rise to acidic gases. Acidic gases attack mucous membranes (eyes, mouth and lungs), that will incapacitate people and restrict their ability to move from the fire/smoke source. In addition, the acids will attack electrical equipment causing permanent irrevocable damage.

Low smoke emission

Being able to see your way out of a burning building / vehicle is essential. Specifying materials that burn with a low smoke density is imperative. This feature needs to be coupled with low smoke toxicity because a material that gives off a little but very toxic smoke is still deadly. More than 70% of people who die in fires, die by inhaling the smoke. Very few die of burns.

Reducing fire hazards

Fire performance

Fire Performance

Adaptaflex has introduced a set of symbols to help the user specify conduit systems for installations where fire performance is of particular concern.

Each symbol encompasses a range of properties relevant to the high specification materials used in the construction of the conduit:

- **(Inherent) LFH** are products that do not intrinsically burn, i.e. metals like steel and brass
- **LFH** are products that are low smoke Zero Halogen and self-extinguishing
- **E (Enhanced) LFH** products have enhanced LFH properties to meet more stringent standards for smoke and toxicity. Passenger rail and underground stations are more strict than general building requirements
- **S (Super) LFH** products have extremely low smoke and fume properties and comply with Boeing and Airbus Standards in addition to London Underground standards

Rail industry fire standards and meeting specific country requirements

Testing simulates the behaviour of a product when exposed to a fire, in terms of its ability to self-extinguish, its ability to transmit a flame, the quantity of smoke generated and the emission of incapacitating or toxic fumes.

There are six key Standards recognised worldwide as being relevant to conduit products in the rail traction market:

- NFF16-101 (French Standards)
- BS6853:2001 (UK Standard)
- NFPA130 (North American Standard)
- DIN 5510-2 2009 (German Standard)
- 1-085 (LUL – UK Underground Fire Standard)
- EN45545

EN45545 is the European wide which will replace the specific country standards from 2015. Each Rail Authority may have additional requirements over and above the Country specific requirements e.g. Train Italia CEI11170-3, LUL 1-085.

They are in an ascending scale of performance from Low Fire Hazard (LFH) featuring zero halogen through to Super Low Fire Hazard (SLFH) featuring zero nitrogen. In addition, Inherent Low Fire Hazard systems (ILFH) are classified as being all metal systems.



Low Fire Hazard



Enhanced Low Fire Hazard



Super Low Fire Hazard



Inherent Low Fire Hazard

Property	LFH	ELFH	SLFH	ILFH
Oxygen Index ISO4589	31% ≥ OI ≥ 28%	OI ≥ 32%	OI ≥ 32%	Inherent Low Fire Hazard
BS6853 Smoke Density 3m ³	0.02 ≥ A0 ≥ 0.03	0.005 ≥ A0 ≥ 0.02	0.02 A0 ≤ 0.005	i.e. Type S, SS, SPB
Zero Halogen	•	•	•	STC, SSB & SSBGS
Zero Phosphorus	•	•	•	Metallic Conduit & Fittings
Zero Sulphur	•	•	•	
Toxicity Index CIT to EN45545-2	TI ≤ 1.2	TI ≥ 0.9	TI ≤ 0.75	
NFF16-101	I3F2	I2F2	I2F1	

Reducing fire hazards

Materials and Toxicity

Fire Performance

Materials that **can** be used and classified as LFH:

- Polyamide
- PEEK (Polyether ether ketone)
- Megolon

3

Materials which **cannot** be classified as LFH:

- PVC contains Chloride
- So Chloride + Hydrogen (in the air) = HCl
- HCl + Water (in the air) = Hydrochloric Acid

Hydrochloric acid will attack the respiratory system and eyes of the public affecting the ability to evacuate confined spaces. It will also attack computer printed circuit boards controlling safety equipment.

Additional materials that **cannot** be classified as LFH:

- **Polypropylene** - Has high flammability
- **Thermoplastic rubber** - Will produce high levels of smoke
- **Polyurethane** - Produces high levels of smoke

PVC can never be classified as LFH. PU and Polypropylene need additives and flame retardents to get the same performance. In this case the cost will increase significantly and not be as competitive as a true LFH material.

Toxicity

Toxicity is assessed by the measurement of elemental quantities of:

- Carbon Monoxide, Carbon Dioxide, Phosphor, Sulphur Oxides of Nitrogen, Halogens (Chlorine, Bromine, Fluorine)

Halogens

- To be classified as a Zero Halogen product (LSF/LFH) the overall total of Halogens MUST be <0.5%

Toxicity Test Standards

- Standard - 1-085 / BS6853 / NFF16.101
- Test - NF X 70-100-1 &-2:2006

Typical specification values for surface installations

BS6853:1999	Standard	Minimum Value
Smoke	BS6853 D8.3	A0 < 0.061 sq. m/g
Toxicity Index	BS6853 Annex B1	R< 3.6
Halogen content	BS6853 Annex B1	<0.5%
FTI	BS EN ISO 4589-2	>250°C
LOI	BS EN ISO 4589-2	>28%

Minimum values required to maintain fire safety in public installations e.g. airport terminals, rail and bus stations, high rise buildings, shopping malls, hospitals, equipment and data control centres.

Typical specification values for underground installations

LUL 1-085	Standard	Minimum Value
Smoke	BS6853 D8.3	A0 < 0.005 sq. m/g
Toxicity Index	BS6853 Annex B1	R< 1
Halogen content	BS6853 Annex B1	<0.5%
FTI	BS EN ISO 4589-2	>350°C
LOI	BS EN ISO 4589-2	>40%

Higher level values required to maintain fire safety in public installations, e.g. airport terminals, rail and bus stations, high rise buildings, shopping malls, hospitals, equipment and data control centres and the minimum required for tunnels and underground installations.

Reducing fire hazards

EN45545

EN45545 - What subjects will the new standards cover?

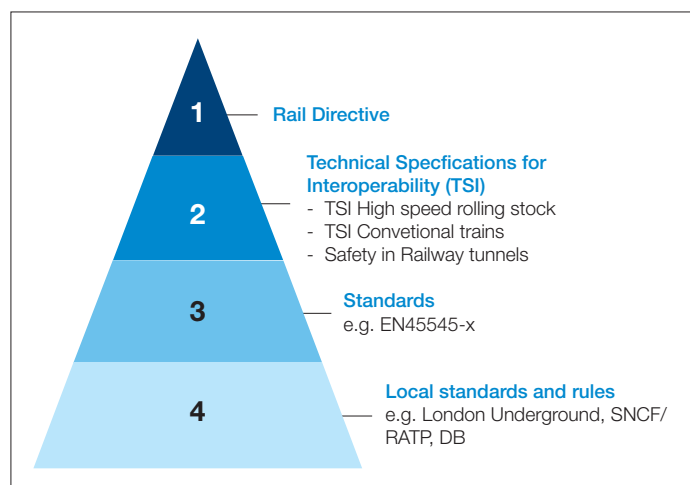
EN45545 is the most comprehensive set of fire safety standards ever developed. There will be 7 parts to the Standard but only Parts 1 and 2 will be applicable to conduit systems:

Part 1: General definitions, operation and design categories, and fire safety objectives

Part 2: Reaction to fire performance requirements of products This new standard will harmonise the requirements for fire safety on railway vehicles that operate within Europe.

What fire properties will be required for European rail products?

EN 45545-2 is the part of the existing series EN 45545-1 to -7 for testing materials. National standards are still valid and allowed for specification until March 2016. Afterwards EN45545-x:2013 has to be used (where specified in the TSIs). Customers can require additional standards like London Underground engineering standard.



Today TSI High Speed does mention the EN 45545-2, all others not. TSI conventional trains is currently in the process to be merged with TSI High Speed. This means EN 45545-2 will be **mandatory** in Europe for high speed and conventional trains. It will **not** be mandatory for:

- Light rail (trams)
- Tunnels
- Infrastructure

The fire properties of products installed on future European railway vehicles are specified in Part 2 of EN45545. The essential reaction to fire properties detailed are aimed at limiting the fire growth through the train if an ignition event occurs and to provide sufficient time for passengers and staff to reach a place of safety. The satisfactory reaction to fire performance will be determined by flame spread, rate of heat release, smoke and toxic gas generation tests on the train.

The new European Standard for fire safety in rolling stock applications has a very similar character to BS6853 with categorisation of applications to assess risk. Material requirements are adjusted to risk.

Applications are divided into 4 **operation categories**:

1. Over-ground operation with fast evacuation min delay
2. Operation including tunnels or elevated sections with fast side evacuation possibilities
3. Operation including tunnels or elevated sections with slower side evacuation possibilities
4. Operation including tunnels or elevated sections with no side evacuation possibilities

As well as 4 **design categories**:

- N: Standard vehicles
- A: Automatic trains with no personnel
- D: Double decked trains
- S: Sleeping cars

Design / Operation Category	N- Standard Vehicles	A-Automatic vehicles with no emergency	D - Double decked vehicles	S - Sleeping & couchette cars. Double/single decked
1	HL1	HL1	HL1	HL2
2	HL2	HL2	HL2	HL2
3	HL2	HL2	HL2	HL3
4	HL3	HL3	HL3	HL3

The highest risk applications are naturally for a sleeping cars where a passenger would have to be woken before he can be evacuated and operation where side evacuation is not possible. The material requirements for these higher risk applications HL3 are in the areas of flammability, smoke emission and toxicity the highest.

What product performance levels will be required?

Three hazard levels of reaction to fire performance will be required for rail products. These levels relate to the risks associated with the operational category of the vehicle and to the location of the product on the vehicle.

What testing and certification of products will be involved?

All rail products will need to be type-tested to the fire tests specified for their application in the future EN45545 Part 2. Notified Bodies to the rail industry will require test certification from an official fire laboratory for rail products.

Fire performance is only one aspect of performance specification for conduit systems. Products must also be fit for purpose, durable and appropriate for the end use.

Reducing fire hazards

BS ISO 6853:2001 (UK Standard)

3



BS6853:2001

This is the UK passenger rolling stock safety standard. It classifies products for use into three vehicle categories using three tests. There are two main categories of operating environment that represent the perceived likelihood and scale of ignition and hazard. These are:

- **Category I:** Underground which is sub divided into 1a and 1b and
- **Category II:** Surface

These categories have different parameters for internal and external use. Products specified for a high level rating can be used on all lower levels.

Category Ia: Substantial operating periods in a single track tunnel with no side exits to a walkway and escape shafts or sleeper vehicles which operate underground for significant periods, or trains that operate without staff.

Category Ib: Substantial operating periods in a multi-track tunnel with no side exits to a walkway and escape shafts or sleeper vehicles, which do not operate underground for significant periods.

Adaptaflex conduit products that comply with this category are:

- Interior use and exterior use
- PK PEEK type conduit
- LFH-SP covered steel type conduit
- LFH-SPL covered steel type conduit
- **NEW** SPL-EF covered steel type conduit
- S steel type conduit
- SS stainless steel type conduit

Category II: Surface stock with no substantial operating periods in tunnels. Adaptaflex conduit products that comply with this category are:

- PA conduits Adaptaflex LFH nylon type conduit
- PR conduits Adaptaflex LFH nylon type conduit
- PF conduits Adaptaflex LFH nylon type conduit

The fire performance of products used on rolling stock is defined in the Standard. It requires that the flammability, smoke and toxicity are tested and recorded. These three values are then checked against the relevant tables contained within the Standard. Which table to use is determined by product type, its shape or intended use.

When checked against the values in the tables the three results achieved by the product determine its class and where and on what type of vehicle it can be used. Adaptaflex conduit products are defined as minor use materials for interior and exterior use. The classification is achieved with reference to table 7 and 8 of the Standard (see next page).

Reducing fire hazards

BS ISO 6853:2001 (UK Standard)

Table 7 - Interior Classification according to:
Interior minor use minerals of mass 100g to 500g

Test Method	Parameter	Vehicle Category		
		Ia	Ib	II
BS EN ISO 4589-3, Annex A	Flammability Temperature (FT) (min.)	300°C	300°C	250°C
BS EN ISO 4589-2 (see note)	Oxygen Index (OI) (min.)	34%	34%	28%
BS6853 Annex D Small scale test	A ₀ (max.)	0.017	0.027	0.061
BS6853 see Annex B	R (max.)	1.0	1.6	3.6

Note

The preferred method is determination of the Flammability Temperature (FT), but the Oxygen Index (OI) should be used where the behaviour of the material at temperature makes it unsuitable for FT testing.

3

Table 8 - Exterior Classification according to:
Exterior minor use minerals of mass 400g to 2000g

Test Method	Parameter	Vehicle Category		
		Ia	Ib	II
BS EN ISO 4589-3, Annex A	Flammability Temperature (FT) (min.)	300°C	300°C	250°C
BS EN ISO 4589-2 (see note)	Oxygen Index (OI) (min.)	34%	34%	28%
BS6853 Annex D Small scale test	A ₀ (max.)	0.029	0.046	nc
BS6853 see Annex B	R (max.)	1.7	2.7	nc

nc - no criterion



Reducing fire hazards

1-085 (LUL – UK Underground Fire Standard)

3



1-085 (LUL – UK Underground Fire Standard)

Transport for London (London Underground's LU) policy for many years has been to control the fire performance of materials used throughout their Underground system. The latest issue of the London Underground Standard 'Fire Safety Performance of Materials' reference number 1-085 (updated in March 2008) outlines the latest product requirements. These Standards specifically refer to materials installed in underground locations and flammability, smoke and toxic fume emissions.

Conduit systems come under the Non-listed Electro-technical Components (Section 3.3.4). To comply all products must pass all three separate tests on flammability (Limiting Oxygen Index [LOI] or Flammability Temperature Index, [TI]); smoke density (BS6853) and toxicity (BS6853 or EDAX). The latest edition of the Standard states that IF materials achieve the same toxicity standard of BS6853 Class 1A, then it is in full compliance. It has further clarified the differences between the Extensive and Grouped Use (previously General Use) and Limited and Dispersed Use types.

Extensive / Grouped use

If a product is suitable for Extensive and Grouped Use it can be used without constraint in any LU application.

Adaptaflex conduit products that comply with this category are:

- PK conduit - Adaptaflex PEEK type conduit
- LFH-SP conduit - Adaptaflex covered steel type conduit
- LFH-SPL conduit - Adaptaflex covered steel type conduit

1-085 applies to combustible materials only. Steel based products such as S & SS are inherent Low fire hazard and are deemed to comply.

Limited / Dispersed use

Materials qualified for Limited Use can be used in less critical areas or where small amounts of product are required. The latest changes to this standard, particularly the toxicity requirements, will affect many products that historically have been classified for Limited and Dispersed Use.

Reducing fire hazards

NFF16-101 (French Standards)

NFF16-101 (French Standards)

This is the standard used by French and Belgian railways. The standard consists of four tests, two that make up an Ignition rating (I) and two that make up a Fume rating (F).

NFF 16-101 refers to materials used on passenger rolling stock. If the thickness varies between test specimens and the finished product then different results will be obtained from the four tests.

SNCF realise that modern manufacturing may not be able to meet these conditions and as such a grid system is used to assess how close/ acceptable a product is if it does not meet these criteria exactly.

The I rating is determined by a combination of:

- The oxygen index (BS EN 4589-2)
- And/or the glow wire ignition (BS EN 60695-2-11) temperature

The F rating is determined by the calculation of the “Fume Index” IF from the results of:

- The smoke emission (NFX 10-702) and the smoke toxicity (NFX 70-100) tests

The two indices are then compared to a series of grids to determine where the product can be used on the vehicle. A copy of an acceptability grid is shown below with calculations as to the Indices.

Adaptaflex products tested to this standard

- PA type conduit - classification I4F3 (Group II)
- PR type conduit - classification I2F2 (Group IV)
- PK type conduit - classification I2F1 (Unlimited)
- LFH-SP type conduit - classification I3F1 (Group III)
- LFH-SPL type conduit - classification I3F1 (Group III)
- PF type conduit - classification I3F1 (Group III)

Performance Classification Key

Oxygen Index LOI BS 4589	≥70	≥45	≥32	≥28	≥20	<20
Glow wire BS EN 60695-2-11 - no flame after 30 seconds exposure		960°C	960°C	850°C		
Flame persistence < 30 seconds				850°C		

Fume Index IF = Dm (100) + VOF4 (30) + ITC (2)	IF	F Class	I Class					
			I0	I1	I2	I3	I4	I5
Dm = Maximum optical density (uncorrected)	≥ 5	F0				III	II	I
VOF4 = Value of fume obscurement @4mins	≥ 20	F1				III	II	I
ITC = Conventional Toxicity Index	≥ 40	F2			IV	II	II	I
ITC = 100 x ti/C ci	≥ 80	F3		IV	IV	II	II	I
ti = Mass of gas in mg from 1g of material	≥ 120	F4		IV	II	II	I	I
C ci = Critical concentration of gas in m g/m ³	> 120	F5		I	I2	I	I	I

Reducing fire hazards

DIN 5510-2 2009 (German Standard)

DIN 5510-2 2009 (German Standard)

The German rail approval body DB, has its own set of approval criteria. The material is tested simultaneously for flame spread, smoke evolution and flaming droplets in one test. This test method is DIN 54837.

3

The test results are then classified by DIN 5510-2 to give a three-part classification of a material or product as follows:

- S value relates to the flame spread/combustibility (measured by distance of flame propagated)
- SR value corresponds to the smoke evolution figure (Higher the value, lower the smoke)
- ST value corresponds to burning droplets (ST2 = No burning droplets)

Toxicity

In 2004 a toxicity test was added to bring the DIN standard in-line with other European fire regulations. They tested to ISO 5659-2 using a 25Kw/m² pilot flame, the toxicity requirement to be below FED E1 after 15 and 30 30 minutes exposed to the pilot flame.

All the following Adaptaflex products are classified as S4 SR2 ST2:

- PA Lightweight conduit
- PA standard weight conduit
- PA heavyweight conduit
- PF standard weight conduit
- PF heavyweight conduit
- PR standard weight conduit



Reducing fire hazards

NFPA130 Federal Railroad Administration (North American Standard)



NFPA130 (North American Standard)

The following series of tests have been adopted by most US transit authorities as required criteria. Conduit falls under the non-listed section of the standard and need to meet the following test criteria.

Flammability

This is defined by the standard ASTM E 162-12a - Surface Flammability of Materials Using a Radiant Energy Source. Each specimen is mounted into a holder and inclined at 30° from the vertical in front of a 12 x 18 inch gas-fired radiant panel. The orientation of the specimen is such that ignition is forced near its upper edge by a pilot flame, and the flame front progresses downwards.

A factor derived from the rate of progress of the flame-front and the rate of heat liberation by the material under test is calculated as follows and then reported after rounding the average of the tests to the nearest multiple of 5: Transit authorities generally specify a maximum Is acceptance criterion of 35 for general applications.

Smoke Density

This is defined by ASTM E 662-13 -Standard Test Method for the Specific Optical Density of Smoke Generated by Solid Materials. This method of test covers a procedure for measuring the smoke generated by solid materials and assemblies in thickness up to and including 1 inch (25.4 mm). Measurement is made of the attenuation of a light beam by smoke (suspended solid or liquid particles) accumulating within a closed chamber due to non-flaming pyrolytic decomposition and flaming combustion. Results are expressed in terms of specific optical density (Ds), which is derived from a geometrical factor and the measured optical

density (absorbance). Results are given after 1.5 and 4 minutes during the test and the maximum density is recorded.

- Ds 1.5 - specific optical density after 1.5 minutes
- Ds 4.0 - specific optical density after 4.0 minutes
- Dm - maximum specific optical density at any time during the 20 minute test

Transit authorities generally specify a maximum Ds 1.5 of 100 and a maximum Ds 4.0 of 200 in either flaming or non-flaming test mode.

Toxicity

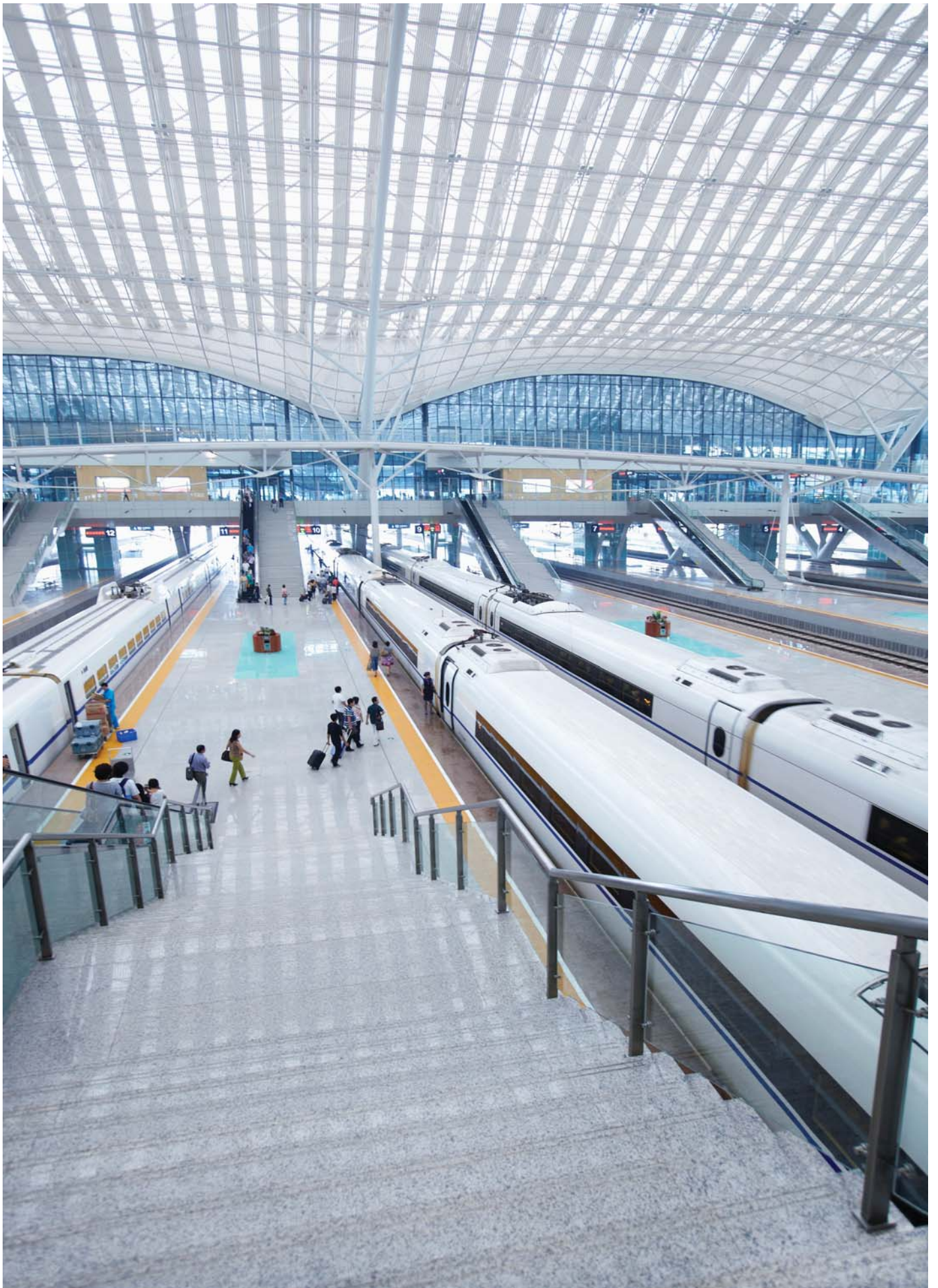
This is measured using the Bombardier standard SMP 800-C (Rev. 6 2009-08-31) - Toxic Gas Sampling and Analytical Procedures. The toxic gases produced for analysis are generated in a specified, calibrated smoke chamber during standard rate of smoke generation testing (typically ASTM E 662), in both flaming combustion and non-flaming pyrolytic decomposition test modes.

The test measures Carbon Monoxide (CO) and Carbon Dioxide (CO₂) Hydrogen Cyanide (HCN), Hydrogen Fluoride (HF), Hydrogen Chloride (HCl), Hydrogen Bromide (HBr) Nitrogen Oxides (NOX) and Sulphur Dioxide (SO₂) against a reference parts per million limit criteria.

The rate of specific heat release as measured by ASTM E1354 may also be required for certain types of material.

Adaptaflex products tested to this standard

- PA type conduit
- PR type conduit
- PF type conduit



Specifying flexible conduit systems

Mechanical & environmental properties

Mechanical & environmental properties

Conduit Classification - IEC61386	4/2
Compression, impact and tensile strength	4/2
Vibration Testing	4/3
Ingress Protection	4/3

Mechanical & environmental properties

Conduit Classification - IEC61386-1 & 23

Conduits are primarily designed to protect cable systems. If the conduit system specified is not the correct type then premature damage can be caused to the cable leading to electrical failure and interruption to systems.

Conduit selection is a serious matter when considering the number of potential mechanical failures, i.e. damage from movement of carriages, flexing, exposure to extreme temperatures and the environment.

4



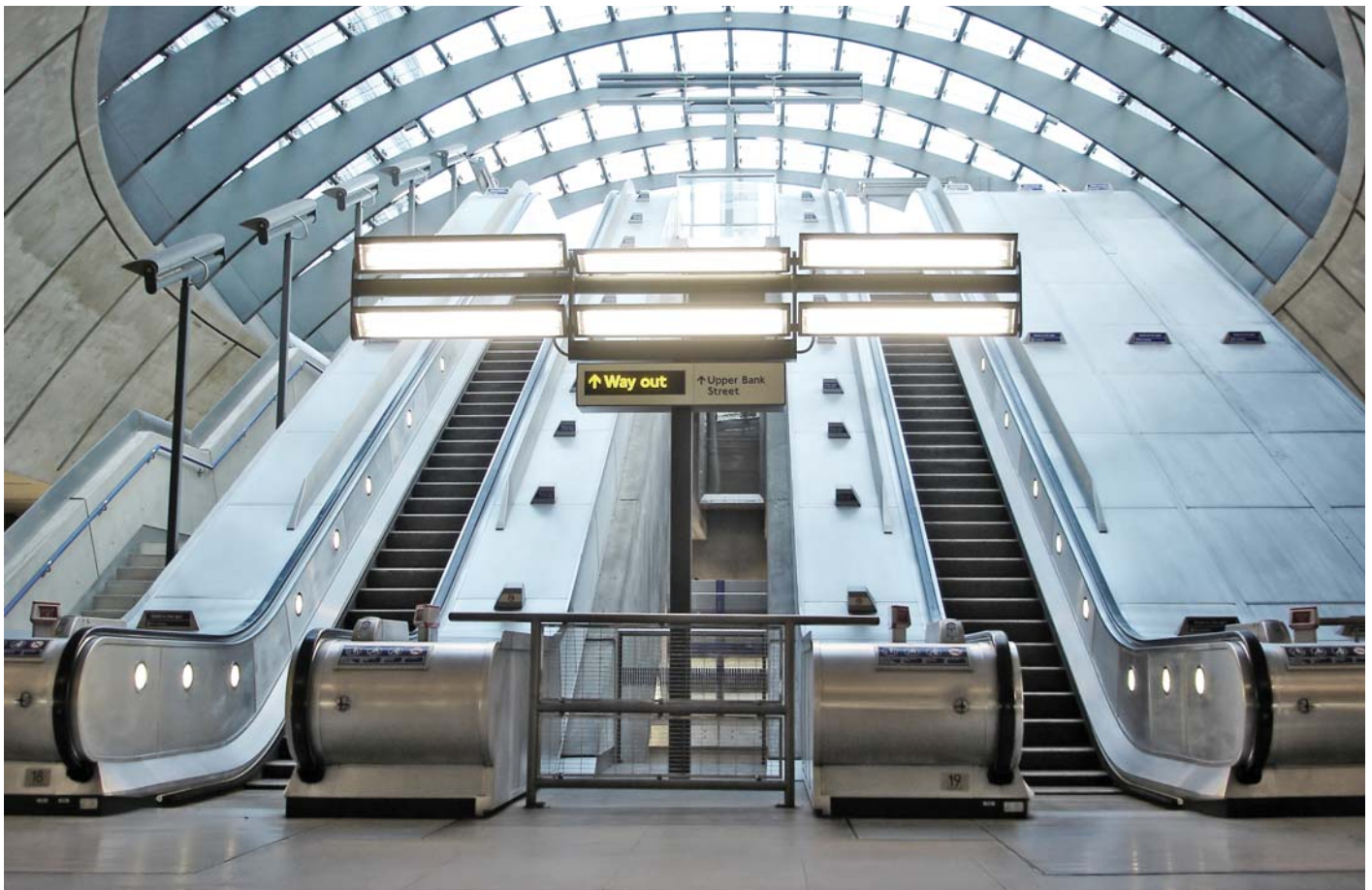
KM35161

Adaptaflex is approved to this Standard through the BSI Kite mark scheme. Our conduit systems are fully assessed and are independently checked annually to ensure continual compliance with this standard.

Conduit classification - IEC61386

The properties tested are:

Compression, impact and tensile strength, classifies the maximum and minimum operating temperatures as well as IP rating for solids and water and corrosion resistance. A minimum flexing requirement for conduits of 5000 reversed bends at the minimum temperature and bend radius is specified for conduits to be classified as flexible.



Mechanical & environmental properties

Conduit Classification - IEC61386-1 & 23

Performance Classification Key

Classification Level	Compression Strength (N)	Impact Strength (J)	Minimum Temperature (°C)	Maximum Temperature (°C)	Bending Properties	Electrical Properties	IP Rating Solids	IP Rating Water	Corrosion Resistance	Tensile Strength (N)	Non-Flame Propagating	Suspended Load Capacity (N)
0						Not declared		0	N/A	Not declared		Not declared
1	125	0.5	5	60	Rigid	Conductor		1	Low	100	4	20
2	320	1	-5	90	Pliable	Insulator		2	Medium	250	7	30
3	750	2	-15	105	Pliable/ Semi Rigid	Con/Ins	3	3	Med-Hi	500		150
4	1250	6	-25	120	Flexible		4	4	High	1000		450
5	4000	20	-45	150			5	5		2500		850
6				250			6	6				
7								7				

Vibration testing

Vibration can be extremely damaging to electrical equipment on rail vehicles. Conduit systems greatly help to reduce the damaging effects on delicate cables and connectors and the interface between them. The conduit system itself needs to be capable of withstanding the forces normally associated in rail vehicle operation to ensure that it is fully capable of protecting this valuable equipment.

Adaptaflex non-metallic conduit systems in combination with ATS fittings have been fully independently tested to BS61373. The tests were carried out, in all axes, on all the non-metallic systems used for rail applications. They have been declared completely suitable for use on body mounted (Class 1a and Class 1b) and bogie operation (Class 2).

Adaptalok metallic systems have been tested and approved to the RIA20 vibration standard.

Ingress Protection

IP ratings are extremely important for protecting electrical equipment from damaging ingress of dust and liquids. ISO 60529 outlines an international classification system for the sealing effectiveness of products against the intrusion into electrical equipment of foreign bodies (i.e. tools, dust, fingers) and moisture. This classification system use the letters "IP" ("Ingress Protection") followed by two digits.

The first digit of the IP code indicates the degree that persons are protected against solid foreign bodies intruding into an enclosure. The second digit indicates the level of protection against the harmful entry of various forms of liquids (e.g. dripping, spraying, submersion, etc.). Additional protection may also be required against high pressure jet washers for cleaning to IP69k introduced into the standard in 2013.

It is important to remember that IP ratings apply in dynamic as well as static applications and that sometimes a higher IP rating that is carried out in static tests may not offer the same level of protection in a continually dynamic situation. The highest IP68 ratings must be defined with a pressure and time of immersion, e.g. IP68 4 bar 30 minutes.

For rail carriages, Siemens have developed their own test specification for conduit, E44010-B0251-U031 which also defines a dynamic IP66 test. This applies the standard IP66 test to an assembly simulating a loaded conduit system flexing at 60 cycles per minute.

Adaptalok systems have been fully tested and not only offer the highest level of ingress protection IP66, IP67 and IP68 4 bar for 30 minutes. They have been approved by Siemens to their dynamic IP66 test and for pressure jet washing IP69k.



Specifying flexible conduit systems

Screening electromagnetic compatibility & interference EMC/EMI

When high voltage cables are used in safety critical systems they need to be protected from electro magnetic interference.

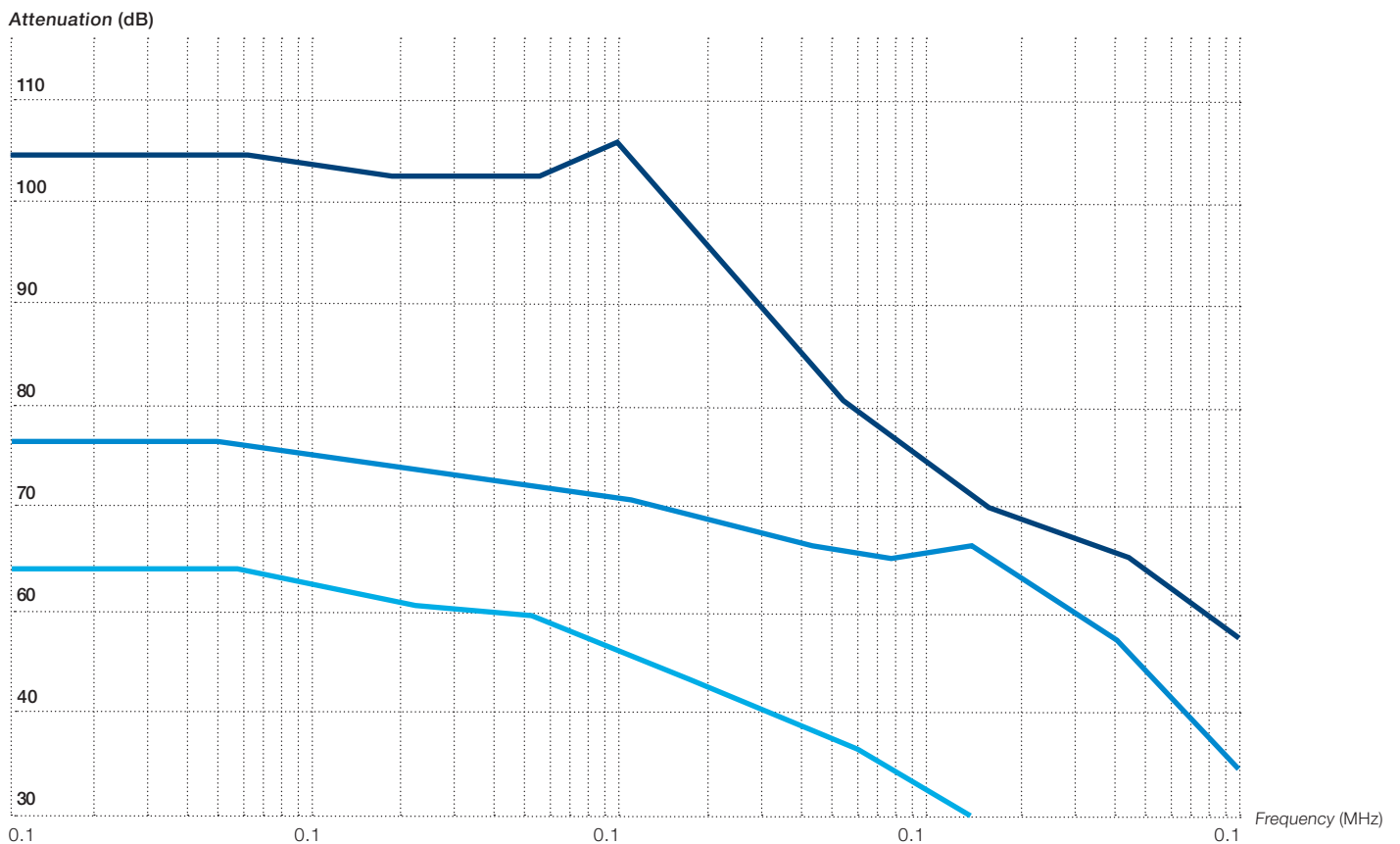
For EMI protection (e.g. For 33 kV power cables) specifying the right conduit can help installers by screening cables running between equipment. This is more cost effective than screened cable where multiple cables are run as they are simpler to install, provide a wide choice of screening levels and have the added benefit of mechanical protection.

Adaptaflex offer galvanised steel (SB), stainless steel (SS) and tinned copper (TC) braided systems which also provide a high degree of mechanical protection.

Adaptaflex Product Recommendation

- PRSS
- PRTC
- PKSS
- PKTC
- LFH-SPSS
- STC type conduit
- SSB
- SPLHCB

Typical EMI Screening Effectiveness of different Adaptaflex metal braids



- Key**
- Tinned copper: ■
 - Galvanised steel: ■
 - Stainless steel: ■

Product selection charts

Non-metallic conduit

Non-metallic Conduit - Product Selection Chart

Conduit	PA	PAH	PIH	PR	PK	PKTC	PKSS	PRTC	PRSS	PRTC	PRSS
Application											
Bogies											
Power - Transmission	-	-	-	-	-	-	•	-	-	-	-
Braking systems	-	-	-	-	-	•	-	•	-	-	-
Equipment monitoring	-	•	•	-	-	-	-	-	-	•	-
Track monitoring	-	-	-	-	-	-	•	-	•	-	•
Carriage Exterior											
Door operation	•	-	-	•	-	-	-	-	-	-	-
Door alarms	-	•	-	•	-	-	-	-	-	-	-
Inter-car jumpers	-	-	•	-	-	-	•	-	-	•	•
Lighting	-	-	-	-	-	-	•	-	-	-	-
Brake tripping devices	-	-	-	-	-	•	-	-	-	-	-
Carriage Interior											
Public address systems	-	-	-	•	-	-	-	-	-	-	-
Lighting	•	-	-	•	•	-	-	-	-	•	-
Heating	-	-	-	-	-	-	•	-	-	-	-
Entertainment systems	-	-	-	-	•	-	-	-	-	-	-
Equipment monitoring	-	-	-	-	•	-	-	•	-	-	-
Air conditioning	-	•	-	•	•	-	-	-	-	-	-
Stations											
Display boards	-	-	-	-	-	-	•	-	-	-	-
Public address systems	-	-	-	-	-	-	•	-	-	-	-
Barriers	-	-	-	-	-	-	-	-	-	•	-
Lighting	-	-	-	-	•	-	•	-	-	-	-
Heating	-	-	-	-	•	-	•	-	-	-	-
CCTV	-	-	•	•	-	-	-	-	-	•	-
Ticket equipment	•	-	-	•	•	-	-	-	-	-	-
Public information systems	-	-	-	-	-	-	•	-	-	-	-
Trackside											
Signals	-	-	-	-	•	•	•	•	•	-	-
Braking system	-	-	-	-	•	•	-	•	-	-	-
Warning systems	-	-	-	-	-	-	-	-	•	-	-
Fire main valves	-	-	-	-	-	-	•	-	-	-	-
CCTV camera to monitor switching	-	-	-	-	-	-	-	-	•	-	•
Radio base stations and amplifiers	-	-	-	-	•	•	•	•	•	-	-
HVAC	-	-	-	-	•	•	-	•	-	•	-
Main power distribution	-	-	-	-	-	-	-	-	-	-	-
Tunnels											
Tunnel lighting	-	-	-	-	•	-	•	-	-	-	-
Tunnel fans and dampers	-	-	-	-	-	-	•	-	-	-	-
Sump pumps	-	-	-	-	-	-	•	-	-	-	-
Fire detection	-	-	-	-	-	•	•	-	-	-	-
Gas detection	-	-	-	-	-	•	•	-	-	-	-
Tunnel ventilation	-	-	-	-	-	•	•	-	-	-	-

NOTE: These are general product recommendations - For Specific guidance for your applications contact our Technical Department

Product selection charts

Metallic conduit

Metallic Conduit - Product Selection Chart

Conduit											
Application	S	SS	LFH-SP	LFH-SPL	NEW SPL-EF	SB	STC	LF-SPSS	SSB	SSBGS	SPLHGB
Bogies											
Power - Transmission	-	-	-	-	-	-	-	-	-	-	•
Braking systems	-	-	-	-	-	-	-	-	-	-	•
Equipment monitoring	-	-	-	-	-	-	-	-	•	-	-
Track monitoring	-	-	-	-	-	-	-	-	-	•	-
Carriage Exterior											
Door operation	-	•	-	-	•	-	-	-	-	-	-
Door alarms	-	•	-	-	•	-	-	-	-	-	-
Inter-car jumpers	-	-	-	-	•	-	-	-	-	-	•
Lighting	-	•	-	-	•	-	-	•	-	-	-
Brake tripping devices	-	-	-	-	•	-	-	•	-	-	•
Carriage Interior											
Public address systems	-	-	•	•	•	-	-	•	-	-	-
Lighting	•	-	-	-	-	-	-	-	-	-	-
Heating	-	-	-	-	-	•	-	-	-	•	-
Entertainment systems	-	•	-	-	-	-	-	•	-	-	-
Equipment monitoring	-	-	•	•	•	-	-	-	-	-	-
Air conditioning	-	•	•	•	•	-	-	-	-	-	-
Stations											
Display boards	-	•	•	•	•	-	-	•	-	-	-
Public address systems	-	•	•	•	•	-	-	•	-	-	-
Barriers	•	-	-	-	-	•	-	-	-	•	-
Lighting	-	•	-	-	-	-	-	•	-	•	-
Heating	-	-	-	-	-	•	-	-	-	•	-
CCTV	-	-	•	-	•	-	-	•	-	-	-
Ticket equipment	-	•	-	-	-	-	-	•	-	-	-
Public information systems	-	•	•	•	•	-	-	•	-	-	-
Trackside											
Signals	-	-	•	•	•	-	-	•	-	-	-
Braking system	-	-	-	-	-	-	-	-	-	-	•
Warning systems	-	-	•	•	•	-	-	•	-	-	-
Fire main valves	-	-	-	-	-	-	-	-	•	-	-
CCTV camera to monitor switching	-	-	•	•	•	-	-	•	-	-	-
Radio base stations and amplifiers	-	-	•	•	•	-	-	•	-	-	-
HVAC	-	•	-	-	-	-	-	-	-	-	-
Main power distribution	-	-	-	-	-	-	-	-	-	-	•
Tunnels											
Tunnel lighting	-	-	•	•	•	-	-	•	•	-	-
Tunnel fans and dampers	-	-	•	•	•	-	-	•	-	-	-
Sump pumps	-	-	-	-	-	-	-	-	•	-	-
Fire detection	-	-	-	-	-	-	-	•	-	-	-
Gas detection	-	-	-	-	-	-	-	•	-	-	-
Tunnel ventillation	-	-	•	•	•	-	-	•	-	-	-

NOTE: These are general product recommendations - For Specific guidance for your applications contact our Technical Department





Adaptaflex
Flexible conduit systems
for critical power &
data cable protection

Glossary of Terms

ASTM E-162

American flame spread / flammability test for panels / large planar objects.

ASTM E-662

American toxicity test for panels/large planar objects.

BS6853 Smoke density

UK Rolling stock standard requirement: Three sets of criteria depending on where the rolling stock will be used. Flammability smoke and toxicity are covered.

BSS7238 & 9

Boeing's smoke and toxicity tests - sometimes used by North American Transit Authorities.

DIN5510-2

Classification for German railways, for tests done to DIN54837.

Glow wire test

Product test where a heated wire at set temperatures is applied to the product. The product must self extinguish within a set time after the wire is removed. The time of application depends on the thickness of the product. Required for NF testing.

Halogen free

Halogens, Phosphorus, Sulphur and Nitrogen have the potential to generate toxic and/or corrosive gases when burnt. Many organisations ban materials containing one, some or all of these elements. The LFH cable standard for halogens is <0.5%.

Heat release rate (RHR)

Heat release is the indication of contribution to a fire and therefore very important for fire engineering purposes. The lower the value the better although time to ignition is also important. Not used as pass/fail criteria but used in conjunction with other test data.

IEC61386

European Conduit standard requires finished product to be tested. This is essentially a Vertical burn tests, which has a pass or fail criteria. Only addresses flame spread & ignition.

ISO 5660 – Cone calorimeter test

Assesses rate of heat release on combustion - This will be included in the harmonized EN45545 standard.

Oxygen Index - a measure of flammability

The amount of Oxygen required to support combustion, the higher the value the better. Any material with an Oxygen Index of 21% + will be self-extinguishing. ISO 4589-2 is a standard to determine Oxygen Index.

SNCF I Rating

"Ignition" Rating gives ignitability of material with the Lower the value the better. Scale is I5 to I0.

SNCF F Rating

"Fume" Rating gives smoke and toxicity (Combined). Scale F5 to F0 with lower value meaning lower smoke and toxicity. Both above form a grid I & F reference, e.g. the minimum requirement for SNCF Tunnel Rolling stock is I2F2.

Temperature index

The temperature required to support combustion, the higher the value the better.

EN45545

Harmonized European fire standard for rail systems.

UL94 Vertical burn

This is the American Underwriters Laboratories' rating standard for flammability of a material. The ratings range from HB (Horizontal burn) to V2 and V0 (Self extinguishing with no flaming droplets).

Notes on smoke tests

ASTM E-662, NFX10-702 and BSS7238 are tests that use the same (1m³) smoke chamber. The only difference is the time at which the smoke density is measured or in the case of NFX, the heat source. E-662 and BSS7238 both use a heat source that is poor in terms of the data repeatability and reproducibility. NFX is the preferred test in Europe and the rest of world, whereas the USA and Canada still use ASTM/ BSS. BS6853 uses a 3m³ chamber and as such the smoke test is more representative. Also BS6853 has a tighter requirement for smoke emission than the other tests.

Notes on flammability tests

ASTM E-162 uses a flat planar specimen of 18"x 6" it was designed to assess the flammability of wall, ceiling, seat & floor panels. It is impractical when referring to nonplanar objects. Preferred methods are Oxygen Index (The amount of oxygen required to continue combustion) and Glow wire. (Simulating electrical fire sources). For conduit there is already a flammability.



Notes

A series of horizontal dotted lines for writing notes.

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