SI-KA-TEC®
GmbH · engineering coating

S-flex
specially coated
textiles
for bellows

S-flex specially coated textiles for bellows

Picture with courtesy of Bavo

Under the *S-flex* product group, different specially coated textiles meeting the most demanding requirements are offered.
These coated fabrics are used in the manufacturing of train bellows, train gangway joints, inter-vehicle gangways articulated bus bellows and flexible connections for passenger boarding bridges (PBB's) on aircraft.

During the selection of the appropriate material, knowledge of the applicable fire prevention standards subject to national regulations is the top priority.

In addition, numerous mechanical performance tests are also made on the materials for the *S-flex* series. Mechanical stresses, buckling behaviors and abrasive stresses are the most important mechanical characteristics.
Cleaning behavior and external environmental influences from sunlight, rain, and other environmental impacts are other important characteristics that are tested on the *S-flex* series.

Fire behavior properties and criteria for the selection of bellows materials

The established applicable standards in this respect are the British BS 6853, the German DIN 5510, the French NF F 16-101, the new European Standard EN 45545-2 and the American ASTM and NFPA 130 standards, respectively.

Within our range of products practically all pertinent norms and standards are offered.
SI-KA-TEC GmbH, in addition to its standard range of products, can also meet your customized requirements upon receipt of your specifications.

Generally, the applied special silicone rubber products manufactured by SI-KA-TEC GmbH, for the *S-flex* materials, exhibit superior behavior over all other polymers currently in use. Silicone has inherent advantages arising from its material due to its chemical composition, which is not based on a hydrocarbon chain. This is reflected in its characteristics regarding fire propagation as well as in the release of smoke and toxic gases. In all respects, silicone's favorable behavior is a given.

SI-KA-TEC GmbH will analyze your specifications in order to propose a customized solution, helping you to manufacture the best bellows for your transport or industrial application.

The rest of this brochure following below shows the specifications to be complied with for the most important standards in their respective categories.

01. European Standard
EN 45545
Railway application – Fire protection
on railway vehicles

This EN Technical Specification utilizes the existing fire safety regulations for railway vehicles from the International Union of Railways (UIC) and of different European countries.

European Norm EN 45545 contains the principal terms and definitions and general regulations governing the classification of railway vehicles in operational and design categories, as well as fire safety objectives.

Operation Category 1:
Vehicles that are not designed or equipped to run on underground sections, tunnels and / or elevated structures, and which may be stopped with minimum delay, after which immediate side evacuation to a place of ultimate safety is possible.

Operation Category 2:
Vehicles that are designed or equipped to run on underground sections, tunnels and / or elevated structures, and where there are stations or emergency stations reachable within a short running time.

Operation Category 3:
Vehicles that are designed or equipped to run on underground sections, tunnels and / or elevated structures, and where there are stations or emergency stations reachable within a long running time.

Operation Category 4:
Vehicles that are designed or equipped to run on underground sections, tunnels and / or elevated structures, and where there is no possibility of evacuation.
In addition to the operation category, rail vehicles are also categorized by design:

A: Vehicles forming part of an automatic train and having no emergency trained staff on board.

D: Double decked vehicles

S: Sleeping / couchette vehicles

N: All other vehicles (standard vehicles)

The operation and design categories defined in CEN TS 45545-2 (2009) are used to establish hazard levels which are used as the basis of a classification system. For each hazard level, this standard specifies the test methods, test conditions and reactions to fire performance requirements.

01.1 Fire Hazard Level Values

Fire hazard level values (HL1 to HL3) derived from operation and design categories shall take into account the different dwell times. The higher the number the higher the requirements are.

Design Category	S: Standard vehicles	A: Automatic vehicles having no emergency trained staff on board	D: Double decked vehicles	S: Sleeping and couchette cars – double decked or single deck
Operation Category				
1	HL1	HL1	HL1	HL2
2	HL2	HL2	HL2	HL2
3	HL2	HL2	HL2	HL3
4	HL3	HL3	HL3	HL3

Table 01: Relations between operation categories and fire hazard levels (HL) according European Standard

Summary of National Standard

01.2 (EN 45545-2)
Describes the requirements for the fire behavior of materials and components.

This part specifies the test procedures, test conditions and the requirements for each hazard level in terms of fire behavior. The requirements are currently specified in 25 levels (R1-R 25). The contents of the requirement set for *S-flex* material are listed in the table below.

ISO 5658-2
Lateral flame spread
Lateral flame spread is determined on vertically oriented specimens using a rectangular radiant panel and an additional gas burner flame as an ignition source.

The assessment is based on the CFE value – critical heat flux at extinguishment. This value is determined by measuring the maximum flame spread.

ISO 5660-1
Heat release rate (Cone calorimeter test)

ISO 5660-1 specifies the method for assessing the heat release rate of a specimen exposed in the horizontal orientation to controlled levels of irradiance with an external igniter. The heat release rate is determined by the measurement of oxygen consumption. The time to ignition (sustained flaming) is also measured in this test.
Two different irradiance levels are imposed by an electric heater: 50 and 25 kW/m^2.
The assessment is based on MARHE – maximum rate of heat emission.

Category	Test method / limits									
	ISO 5658-2		ISO 5660-1		ISO 5659-2					
	CFE		MAHRE		Ds (4 min)	Ds max	VOF 4		CIT	
level	R1	R7	R1	R7*	R1	R7*	R1	R7	R1	R7*
HL1	> 20	N/A	N/A	N/A	< 600	N/A	< 1200	N/A	< 1,2	N/A
HL2	> 20	N/A	< 90	< 50	< 300	< 600	< 600	N/A	< 0,9	< 1,8
HL3	> 20	N/A	< 60	< 50	< 150	< 300	< 300	N/A	< 0,75	< 1,5

Table 02: A set of requirements for the S-flex product group according EN 45545-2 level R1, R7 ** to be tested at 25 KW/m^2*

Vertical spread of flame testing of the S-flex product group material according to BS 476 Part 7 Class 1. Heat radiation during the 25 kW / m^2 test.

Flame testing of the S-flex product group material according to BS 6853.

Surface of the S-flex 210 after a 40-minute long smoke density test in compliance with BS 6853 after the flame exposure.
The surface resists the flame load, and no cracks in the material are visible.

EN ISO 5659-2
Smoke optical density and toxicity test

This test specifies a method of measuring smoke production from the exposed surface of specimens of essentially flat materials, composites or assemblies not exceeding 25 mm in thickness when placed in a horizontal orientation and subjected to specified levels of thermal irradiance in a closed cabinet with or without the application of a pilot flame.
The duration of the test is 20 minutes, and optical density is measured by an optical system. Toxic effluents are analyzed by FTIR spectroscopy in the 4th and 8th minutes.

For specimens to be tested at 50 kW/m^2 without the pilot flame, two values are measured – Ds (4), the optical density at 4 minutes, and VOF4, integral of the Ds (t) curve calculated from 0 to 4 minutes.

For specimens to be tested at 25 kW/m^2 without the pilot flame, one parameter is measured – Dsmax, maximum optical density.

Smoke toxicity
Gas sampling takes place at 4 and 8 minutes after the test has started, and 8 components are quantitatively analyzed: CO_2, CO, HF, HCl, HBr, HCN, NOx, and SO_2.

The assessment of toxicity is based on the CIT value – Conventional Index of Toxicity.

02. British Standard
BS 6853
Code of practice for fire precautions in the design and construction of passenger carrying trains

This British standard makes recommendations in respect to fire safety for the design and construction of railway vehicles comprising or forming part of passenger carrying trains.

Classification of vehicle categories
There are two main classes of operating environment, and they are designated as follows:

Category I: Underground
Category II: Surface Materials:
Materials are classified into one of a limited number of types as determined by their position on the vehicle, and the type assigned determines the test regime that is to be applied.

For our *S-flex* product group, Table 03: Interior Vertical Surfaces applies.

Category	BS 476 Part 6	BS 476 Part 7	BS 6853 D8.4	BS 6853 B.2
Ia	I_1 6 I 12	Class1	A_0 (on) < 2.6 A_0 (off) < 3.9	R 1.0
Ib	I_1 6 I 12	Class1	A_0 (on) < 4.2 A_0 (off) < 6.3	R 1.6
II	No criteria	Class1	A_0 (on) < 9.4 A_0 (off) < 14.0	R 3.6

Table 03: Set of material requirements for British Standard

03. French Standard
NF F 16-101
Fire Test to Railway Components

The purpose of this standard is to establish rules relating to the choice of all non-metallic materials, with the exception of paintwork, according to their fire behavior with regard to reaction to fire, opacity of smoke, and toxicity of gases emitted.

This classification involves substantially three vehicle categories:

A1: All rolling stock, including their drivers' cabins, which travels frequently though tunnels
A2: Urban and suburban rolling stock which travels infrequently through tunnels
B: Mainline rolling stock, including locomotives, which travels infrequently through tunnels

This standard provides the classification of the material by "reaction to fire" and "smoke" (combination of smoke opacity and toxicity). The product of the above parameters determines the "risk index".

Reaction to fire test
For wide specimens, the "reaction to fire" tests classify the material/product into one of six categories from M0 to M5 and are obtained from a combination of the parameters being measured.

For small specimens which are not able to be assessed with the M rating, two tests are used: the Oxygen Index (NF EN ISO 4589-2) and the glow wire test (NF EN 60695-2-10). These tests classify the materials into five classes from I0 to NC.

Smoke parameters
Concerning the "smoke" parameter, this is obtained from the combination of "smoke emission" and the "toxicity index". The first one is evaluated by the NF X 10 702 (Smoke Density Chamber) and the second one with NF X 70-100. The assessment of smoke toxicity is focused on CO, CO_2, HCl, HBr, HF, HCN, and SO_2.
NO_x - Each of the gas concentrations is divided by an – acceptable – value and then summed to determine the toxicity index called the ITC.

The smoke emission index is a combination of the maximum optical density Dm and the summation of optical density up to 4 min, VOF4. These two parameters Dm and VOF4 are assessed during the smoke chamber test.
The toxicity results are then combined with the smoke emission results. And, at last, these three indices ITC, VOF, and Dm form a smoke index, IF.

According to NF F 16-101, the combination of the smoke index and the toxicity index gives the "smoke value" with classes from F0 to F5.

IF value	IF rating
< 5	F0
< 20	F1
< 40	F2
< 80	F3
< 120	F4
> 120	F5

Table 04: F rating according IF values

Our *S-flex* group material met the F1/M1 fire performance requirements specified in this standard.

04. American Standard
NFPA 130
Standard for fixed guideway transit and passenger rail systems

This standard covers fire protection requirements for passenger rail, underground, surface, and elevated fixed guideway transit stations, and vehicle maintenance and storage areas. This standard establishes the minimum requirements for each of the identified subsystems.

All new articulation bellows shall be, at a minimum, designed and constructed to conform with the requirement set listed in the table below.

Category	Function of material	Required testing	Test method
Other vehicle components	Articulation bellows	Surface flammability	ASTM E 162
		Smoke density	ASTM E 662

Table 05: Test procedures for testing the Flammability and Smoke Emission Characteristics of Articulated Bellows as a part of Rail Transit Vehicle Materials

ASTM E 662	1.5 min : Ds ≤ 100 4.0 min : Ds ≤ 200
ASTM E 162	1.5 min : I_s ≤ 35

Table 06: Minimum Performance Requirements for Testing the Flammability and Smoke Emission of Articulated Bellows

These minimum fire performance requirements assess the legal limits of *S-flex* material for the U.S. and, also in particular cases, the Canadian markets. These requirements are also partially applicable in Asia.

SMP 800-C Smoke-gas toxicity test

SMP 800-C describes the maximum permissible values of toxic smoke gases when a plastic is burned. The smoke gases of these measurements are taken from the NBS test chamber of the ASTM E 662 test.

SMP 800-C limit values of toxic smoke gases in ppm:

Carbon monoxide (CO)	3500
Carbon dioxide (CO_2)	90000
Nitrogen oxides (NOX)	100
Sulphur dioxide (SO_2)	100
Hydrogen Chlorid (HCl)	500
Hydrogen Bromid (HBr)	100
Hydrogen Fluorid (HF)	100
Hydrogen Cyanide (HCN)	100

ASTM E 622
Standard Test Method for Specific Optical Density of Smoke Generated by Solid Materials

This test method provides a means for determining the specific optical density Ds of the smoke generated by solid materials and assemblies, which are mounted in the vertical position in thicknesses up to and including 1 inch (25.4 mm) under specified exposure conditions.

ASTM E162
Surface Flammability of Materials Using a Radiant Heat Energy Source

This test method provides a test procedure for measuring and comparing the surface flammability of materials when exposed to a prescribed level of radiant heat energy.
The test uses a radiant heat source to determine the surface flammability of materials. The surface spread of flame towards the lower end of the specimen is then determined. The final flame spread index, Is, is the result of the flame spread factor, Fs, multiplied by the heat generation factor, G.

05. American Standard
NFPA 415
Standard on Airport Terminal Buildings, Fueling Ramp Drainage, and Loading Walkways

This standard specifies the minimum fire protection requirements for the construction and protection of airport terminal buildings. It specifies the minimum requirements for the design and maintenance of the drainage system of an aircraft fueling ramp to control the flow of fuel that can be spilled on a ramp and to minimize the resulting possible danger. In addition, it contains the minimum requirements for the design, construction, and fire protection of aircraft loading walkways between the terminal building and the aircraft.

The objective of the fire test is to evaluate the fire performance of a flexible closure material used on aircraft loading walkways.

06. American Standard
NFPA 701
Standard Methods of Fire Tests for Flame Propagation of Textiles and Films

This test measures the flammability of a fabric when it is exposed to specific sources of ignition.
NFPA 701 (Test Method 1, the replacement for the original Small Scale) measures the ignition resistance of a fabric after it is exposed to a flame for 12 seconds. The flame, char length, and flaming residue are recorded. The fabric will pass the test if all samples meet the following criteria:

1. An after flame of less than 2.0 seconds
2. A char length of less than 6.5”
3. The specimen does not continue to flame after reaching the floor of the test chamber.

07. FMVSS 302
Flammability of Interior Materials – Passenger Cars, Multipurpose Passenger Vehicles, Trucks, and Buses

This standard specifies the burn resistance requirements for materials used in the occupant compartments of motor vehicles. The test is conducted inside a test chamber where the test specimen is mounted horizontally. The exposed side of the test specimen is subjected to a gas flame from underneath. The burnt distance and the time taken to burn this distance is measured during the test. The result, the burning rate, is expressed in mm/min.

The material will pass the test if all samples meet the following criteria:
Burning rate of less than 250 mm / min.

08. FAR / JAR 25.853

FAR 25.853a is a vertical Bunsen burner test designed by the FAA (Federal Aviation Administration) for cabin and cargo compartment materials. The test method is intended for use in determining the resistance of materials to flame when tested according to the (i) 60-second and (ii) 12-second vertical Bunsen burner tests.

In this test a specimen is held in a vertical position by a device inside a cabinet, and a Bunsen burner is placed beneath it for a given period of time (60 or 12 seconds accordingly). After the given period of time has elapsed, the burner is removed, and the specimen is observed. Ignition time, flame time, drip flame time, and burn length are all recorded at the end of the test.

The following are the requirements for passing the FAR 25.853a test.

Ignition time	Flame time	Average drip extinguishing time	Average burn length
12 s	< 15 s	< 5 s	203.2 mm (8’’)
60 s	< 15 s	< 3 s	152.4 mm (6’’)

Table 07: Requirements for passing the FAR 25:853a test

09. European Standard
EN ISO 9239 -1
Reaction to fire tests for floorings – Part 1: Determination of burning behavior using a radiant heat source

This test specifies a method for assessing the wind-opposed burning behavior and spread of flame of horizontally mounted floorings exposed to a heat flux radiant gradient in a test chamber when ignited with pilot flames.

This method is applicable to all types of flooring, e.g. textile carpet, cork, wood, rubber and plastics coverings as well as coatings.

After a 30-minute test duration, the Critical Heat Flux CHF (kW/m²) related to the maximum flame spread distance is determined, and smoke production is also evaluated.

Fire Class	Classification criteria
B_{fl}	Critical heat flux CHF ≥ 8.0 KW/m², Additional classification S_1 = smoking ≤ 750 % x min
C_{fl}	Critical heat flux CHF ≥ 4.5 KW/m², Additional classification S_1 = smoking ≤ 750 % x min
D_{fl}	Critical heat flux CHF ≥ 3.0 KW/m², Additional classification S_1 = smoking ≤ 750 % x min

Table 08: Experimental classification into relevant Fire Classes, D_{fl} up to B_{fl} based on the testing procedure according to EN ISO 9239 -1

Requirements for Use and Application

Mechanical Load
As there are high mechanical variations in stress acting upon the materials used for bellows, a number of tests must be fulfilled to achieve a long life span during the material's later application.

The so-called Bally-flexometer test is an excellent test for characterizing material behavior during the buckling test. Values of more than 250,000 cycles in an individual case are achieved, whereby a Stage 3 and, in case of special types, a Stage 2 are achieved with materials of the *S-flex* series.

A twist-offsetting test is another mechanical test, giving further details about what occurs in parts during curving movements.

Beyond that, tensile strength and further tear resistance are tested in order to give processing advice, to help establish the firmness of seams and to also establish general resistance values for later use.

An abrasion test on the material is conducted using standardized sandpaper to simulate possible load situations during use.

Temperature Range
Further demands refer to the stability of coatings in cold temperatures.
Especially here, the special silicon used will score favorably compared to the other usually applied polymer systems, such as CSM (HYPALON® DuPont). They can be applied in temperatures as low as -50°C. Relevant tests in compliance with standards show that there is no formation of cracks in the material around the buckling area under static conditions.

Due to the carrier material, the heat load is, however, restricted. By using thermoplastic fibers, an upper temperature limit of a maximum of 100°C is defined. As, however, certain protection is provided for the carrier material by the external coating, higher temperatures from sunlight will also be tolerated. Silicon itself can be exposed to a permanent load of up to 180°C, even much more in extreme cases.

High temperature fibers that may have to be used due to fire requirements can raise the material temperature limit up to 200°C.

Weather Stability
Another outstanding advantage of silicon is that it is resistant to sunlight, ozone impacts and rain, as well as to organic acids. Due to this resistance, silicon is being continuously used for many years compared to all other polymer systems (CSM, PVC). Also, there is no bleeding of oils or softeners.

Environmental Compatibility and Toxicology
Due to its chemical structure based on -Si (CH3)-O-, silicon is by nature classified as not being toxic. Its fission products are mainly H_2O (water), CO_2 (carbon dioxide), and SiO_2 (silicon oxide) when burned. This is an enormous advantage compared to the polymers based on CSM and PVC, for example, where halogenated hydrocarbons or even toxic nitrogen may be produced.
Our special silicon formulation for *S-flex* series achieve excellent toxicity results.

Cleaning Behavior
As silicon has a low adhesion with many materials, most contaminations are assessed as being unproblematic. Special cleaning agents must, however, be used in case of certain grease or oil contaminations. These cleaning agents should be neutral in any case – or at a maximum - slightly acidic. Alkaline cleaning agents should be avoided as they could attack the coating under certain circumstances.

Noise and Heat Insulation
The products are differentiated by selecting suitable thicknesses. In the last instance, the overall design of the transition zones is decisive with reference to the mentioned criteria and not only to the material itself. The *S-flex* series offers thicknesses from about 1.0 mm to nearly 3.0 mm.

HYPALON® *Reg. Trademark: DuPont Performance Elastomers*

Country	Classification / Test standard	Test compliance / Test results requirements	SI-KA-TEC material performance	Application
Europe	EN 45545-2	Material complies with Table R1 and Table R7 of Interior Surfaces of Gangways (Types A & B)	HL 2 R1 HL 2 R7	Rail gangways, trams
United Kingdom	BS 6853:1999- Cat 1a	Material complies with test mentioned in Interior Vertical Surfaces (Table 02) and Exterior Vertical Surfaces (Table 05)	Cat 1a	Rail gangways, trams
United States	NFPA 130	Complies with smoke and flammability requirements stated in ASTM E662 and ASTM E162	■	Rail gangways, trams, buses
	SMP 800-C	Toxic Gas Generation from Material Combustion	■	Rail gangways, trams
	NFPA 415	No flame penetration, Radiant heat flux < 0.65 W / cm^2	■	Passenger boarding bridges
	NFPA 701	After flame < 2 sec, Char length < 435 mm	■	Buses, passenger boarding bridges
	FMVSS 302	Rate of flame / burning rate = < 250 mm / min	■	
	FAR/JAR 25.853 (A)	12 secs and 60 secs vertical flame test	■	Passenger boarding bridges
Germany	DIN 5510-2	Burning Class classification	S4	Rail gangways, trams
		Droplet classificiation	ST2	
		Smoke Development classification	SR2	
France	NF F-16-101	Smoke and Toxicity F rating	F1	Rail gangways, trams
		Burning Behavior M rating	M1	
South Korea	ISO 4589-2	Oxygen Index	■	Rail gangways, trams
	ISO 5658-2	Spread of flame	■	
		Total Heat Release	■	
	ASTM E 662	Max Smoke @ 1.5 mins	■	
		Max Smoke @ 4 mins	■	
	BS 6853:1999	B.2 Toxicity	■	
Japan	JIS L1092:2009 R	Resistance to surface wetting	Grade 4	Rail gangways, trams, Passenger boarding
		Rain test	Grade 4	
		Water penetration / pressure test (H_2O)	> 1000	

■ *Performance Achieved*

S-flex material
Classification of test results

Country	Classification / Test standard	Test compliance / Test results requirements				Application
United States	NFPA 130	ASTM E162		Is ≤ 35		Rail gangways, trams, buses
		ASTM E662		1.5 mins: Ds ≤ 100 4.0 mins: Ds ≤ 200		Rail gangways, trams, buses
	SMP 800-C (Toxic Gas Generation)	Toxic Gas Generation from Material Combustion				
		Carbon Monoxide (CO ppm) Carbon Dioxide (CO_2 ppm) Nitrogen Oxides (as NO_2 ppm) Sulphur Dioxide (SO_2 ppm) Hydrogen Chloride (Hcl ppm) Hydrogen Fluoride (HF ppm) Hydrogen Bromide (HBr ppm) Hydrogen Cyanide (HCN ppm)		3500 90000 100 100 500 100 100 100		Rail gangways, trams
	NFPA 415	1. The test specimen shall have to withstand the fire endurance test as defined in the standard without the passage of flame for a minimum period of 5 minutes. 2. Measure the radiant heat flux to which a human can be subjected while exiting an aircraft under a fuel spill fire emergency condition. The approximate equivalent human exposure in the walkway shall not exceed 0.65 W/cm_2.				Passenger boarding bridges
	NFPA 701	After flame < 2 sec Char length < 435 mm				Buses, passenger boarding, bridges
	FMVSS 302	Rate of flame / burning rate = < 250 mm / min.				
	FAR / JAR 25.853 (A) Appendix F Part 1 (A) 1 (ii) Vertical Test	Test	Flame Time (sec)	Average Drip Extinguishing Time (sec)	Average Burn Length	Passenger boarding bridges
		(i) 60 sec	< 15	< 3	< 152.40 mm (6")	
		(ii) 12 sec	< 15	< 5	< 203.20 mm (8")	

Country	Classification / Test standard	Test compliance / Test results requirements		Application
United Kingdom	BS 6853: Classification of vehicle categories			
	Category I: Underground	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		Underground trains like the London underground, Korean metros, etc. (most demanding)
		Category Ib: Substantial operating periods in a multi-track tunnel, or a tunnel with side exits to a walkway and escape shafts, or sleeper vehicles which do not operate underground for significant periods		
	Category II: Surface	Category II: Surface stock with no substantial operating periods in tunnels		All surface trains
	Classification / Test standard	Test compliance / Test results requirements		
	BS 6853:1999- Cat 1a	Interior Vertical Surfaces (Table 2)	Exterior Vertical Surfaces (Table 5)	Rail gangways, trams, undergrounds, tube, etc.
	BS 476 Part 6	i1 < 6 , I < 12	i1 < 6 , I < 12	
	BS 476 Part 7	Class 1 (< 165 mm flame spread)	Class 1 (< 165 mm flame spread)	
	BS 6853 D8.4	A_o (on) < 2.6, A_o (off) < 3.9	A_o (on) < 4.4, A_o (off) < 6.6	
	BS 6853 B.2	R < 1.0	R < 1.7	
Germany	DIN 5510-2	DIN 54837 / DIN 5510-2		Rail gangways, trams
		Burning Class classification: (S2-S5) S2: Damage range ≤ 30 cm, no after flame requirements required S3: Damage range ≤ 25 cm, after burning time ≤ 100S S4: Damage range ≤ 20 cm, after burning time ≤ 10S S5: Damage range = 0 cm, after burning time = 0S		
		Droplet classificiation: (ST1-ST2) ST1 = Droplet ST2 = No Droplet		
		Smoke Development classification (SR1-SR2) SR1 ≤ 100 (%*min transmission) SR2 ≤ 50 (%*min transmission)		

Country	Classification / Test standard	Test compliance / Test results requirements					Application
Europe	EN 45545-2 Classification of vehicle categories						Rail gangways, trams
	Operation Category	Design Category					
		N: Standard vehicles	A: Automatic	D: Double decked	S: Sleeping and couchette	Applicable in:	
	1 / Open Area	HL1	HL1	HL1	HL2	Trams	
	2 / Tunnels with side evacuation and short running time	HL2	HL2	HL2	HL2	All subways	
	3 / Tunnels without side evacuation and short running time	HL2	HL2	HL2	HL3	Subways, tube, sleeping and couchette cars	
	4 / Tunnels without side evacuation and long running time	HL3	HL3	HL3	HL3	Sleeping and couchette cars, subsurface trains only	
	EN 45545-2				Table R1 (HL2)	Table R7 (HL2)	
		ISO 5658-2	CFE		> 20	> 20	
		ISO 5659-2	Ds (4.0 mins)		< 300	N/A	
			VOF		< 600	N/A	
			Ds Maximum		N/A	600	
		ISO 5659-2 FTIR	CIT		< 0.9	< 1.8	
		ISO 5660-2	MARHE		< 90	< 90	
Country	Classification / Test standard	Test compliance / Test results requirements					Application
South Korea	ISO 4589-2	Oxygen Index			> 40		Rail gangways, trams
	ISO 5658-2	CFE			> 20		
		Total Heat Release (Qasb)			> 1.5		
	ASTM E 662	Max Smoke @ 1.5 mins			< 50		
		Max Smoke @ 4.0 mins			< 100		
	BS 6853:1999 B.2 (toxicity)	R			< 1.6		

Country	Classification / Test standard	Test compliance / Test results requirements		Application
France	NF F 16-101	NFP 92 504	F0 to F5	Rail gangways, trams
		NFP 92 505		
		NFX 10-702	M0 to M5	
		NFX 70-100		
Japan	JIS L1092:2009	Resistance to surface wetting	Grade 1 - Grade 5	Rail gangways, trams, passenger boarding bridges
		Rain test	Grade 1 - Grade 5	
		Water penetration / pressure test	> 1000 cm (H_2O)	

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