

Slip resistance

How do we define anti-slip? Put simply it is a material with the appropriate performance characteristics to overcome the problem of people falling over in specific environments.



Slip resistance and the onus on the specifier

Over the last few years, increased importance has been placed on designing-out the risk of slipping on floor coverings in commercial applications in regular contact with water, mud, oil and grease, agents which cause floor tiles to have less adherence than if they were dry and had a clean surface.

This section deals with commercial applications rather than domestic: this includes public areas, restaurants and canteens, office reception areas, retail and fashion, shopping centres, commercial kitchens, schools and hospitals, transport and industry.

It has been calculated that the annual cost of slip and trip injuries to society could be over £750 million (more than £360 million directly related to the workplace).

Wherever floor tiles are used, the onus falls on the specifier to choose an appropriate finish in terms of performance and design. There is also a duty of care to provide solutions to potential problem areas where function has to take precedence over form and safety issues override cost.



Current UK legislation

At present, there are no official UK requirements covering the slip resistance of floor coverings. There are various test methods used to determine a tile's 'slip resistance', but to date no method has been universally accepted by either British or European standards. The UK Construction Products Directive has issued a mandate that the issue of slip resistance be fully addressed in future 'harmonised European Standards'.

The various test methods and schools of classification

Among the various methods used are the following:

- The ASTM 1028 American test method
- The P-17 French test method
- The BCR Tortus test
- Pendulum Test
- DIN 51130 and 51097: the German test methods

ASTM 1028 American test

This method of measurement establishes the 'Static Co-efficient of Friction', and involves pulling a weighted block of wood with a rubber attachment across a tile, calculating as it moves, the amount of energy absorbed, resulting in the co-efficient of friction. This is carried out in a number of positions on the tile and then averaged.

The anti-slip qualities of this tile is then graded as follows:

0 to 0.5	Slippery product
0.5 to 0.6	Non fully safe
> 0.6	Excellent friction

There are various criticisms of this test method. Firstly, it is considered unscientific. Secondly, the pulling of the block is done manually and this automatically leaves the test open to variance. The bands at either end of the scale are so broad as to render them almost meaningless. Also, can a tile with the coefficient of 0.49 really be that much more dangerous than one with the coefficient of 0.61? Finally, there are no guidelines as to what level is required in specific areas.

The French method or P-17

This is geared towards determining the friction coefficient of a floor surface using the inclined plane system, in conditions which are rather subjective.

The BCR Tortus test

In Italy the Tortus is so called because of the instrument used. It is a precision instrument developed in the UK in the 1970's by Ceramic Research. The Tortus is a self propelling device which measures the dynamic co-efficient of friction as it moves across flat or relief surfaces. The test method therefore reproduces the conditions under the heel at the critical moment when it first contacts the floor, and is usually carried out using both a leather element in dry conditions and a (Four S) rubber element on a wet surface.

The scale of co-efficient of friction values is as follows:

$0 < m < 0.19$	Dangerously slippery
$0.20 < m < 0.39$	Excessively slippery
$0.40 < m < 0.74$	Satisfactory friction
$0.75 < m$ and above	Giving excellent friction

The TRRL Pendulum method

The Pendulum Test was specifically developed in the UK by the Transport Road & Research Laboratory to provide highway engineers with a routine method of checking the resistance of wet road surfaces to skidding.

This method, preferred by the Australians and the UK Slip Resistance Group, consists of a pendulum-shaped apparatus that is allowed to fall from a certain angle so that it rubs against the surface that is being tested. A Four S rubber cap is fitted on its end, and it is allowed to fall in a pendular arc; depending on the height reached after rubbing against the tested surface, a value is obtained that will be used to classify it.

Slip resistance is then interpreted as follows:

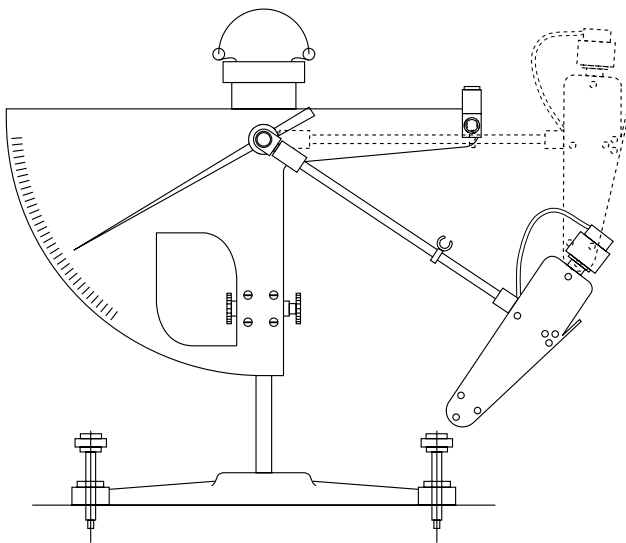
Pendulum numbers	Slip resistance
0 to 24	Dangerous
25 to 34	Marginal
35 to 64	Satisfactory
65 and above	Excellent

This test is also the one often preferred by UK scientists/consultants involved in the tiling industry and also London Underground, as it is considered very exacting.

However over the last decade there have been two camps firmly entrenched against each other, one siding with the Tortus and one with the Pendulum. The Health and Safety Executive refuses to accept that the Tortus is accurate in wet conditions and rely on the Pendulum test instead.

Also, the Pendulum Test can give misleading results on tiles with profiled surfaces. Measurements can be disrupted by the size of the raised profile area, the ratio of high to low areas (distance apart), and the shape of the profiles themselves (round or square edges).

The Pendulum Test does appear in several British Standards, but none relating specifically to floor tiling. The 2003 edition of BS 7932 covers the Pendulum Test method with the scope extended to include unpolished surfaces. Previously known as the slip resistance value (SRV), the test now provides unpolished and polished pendulum test values (PTVs) for single surfacing units of clay, concrete or natural stone.



AS/NZS 3661.1 – The TRRL Pendulum method test

Surface roughness

Surface roughness can produce an improvement in slip resistance in wet or contaminated conditions. For example, polished stone has a surface roughness (Rz) value of less than 2 micrometres. A value of 4 micrometres is required to provide a slip resistance value (SRV) greater than 20. The top table relates 'potential for slip' to pendulum values and surface roughness. A surface contaminated with water requires a surface roughness value of 10 micrometres to provide reasonable slip resistance.

Contamination by more viscous materials requires higher values to achieve reasonable slip resistance with contaminants of various viscosities. The bottom table (reproduced from BS 5395-1) shows the levels of surface roughness required to achieve reasonable slip resistance with contaminants of various viscosities.

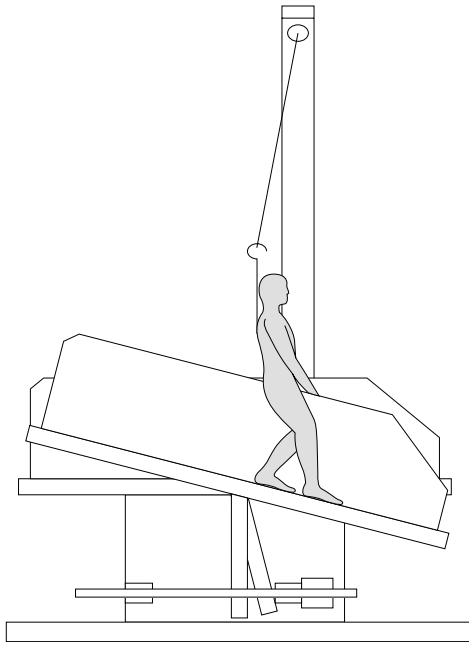
Slip resistance is likely to change with use. Surfaces may develop lower slip resistance values through wear or surface treatment, polish, sealer etc.

Four S pendulum value, surface roughness values and potential for slip

Pendulum value	Potential for slip	Surface roughness (Rz) (micrometres)
<25	High	Less than 10
25 to 35	Moderate	10 to 20
35 to 65	Low	21 to 30
>65	Extremely low	Greater than 30

Minimum levels of Rz roughness necessary to provide reasonable slip resistance in the presence of various contaminants.

Contaminant viscosity (mPa-s)	Typical contaminant	Min Rz floor roughness micrometres
≤ to 1	Clean water	20
1 to 5	Milk	45
5 to 30	Stock	60
30 to 50	Olive Oil	70
≥50	Margarine	70



Inclined ramp test

**DIN 51130 and 51097 – the German methods
(also known as the ramp tests)**

DIN 51130 is used for testing shoe-trafficked areas over a surface lubricant, where a person walks back and forth on a platform (in a laboratory) covered with tiles. The angle of inclination of the test area is steadily increased until the person begins to slip. The angle at which the person slips is recorded and averaged out over a number of tests.

The DIN classification (known as R ratings) is as follows:

R9	3 to 10°	
R10	10 to 19°	
R11	19 to 27°	
R12	27 to 35°	
R13	>35°	

The higher the rating, the more a tile may be considered anti-slip. DIN 51130 then relates these R ratings to particular fields of use. A summary of these fields of use is given in the table opposite. Generally, R9 is the accepted minimum for use of a tile in a public areas and that is why most of Europe uses this test – it is the easiest to understand. Specifiers of flat, dry installation need to ensure the tiles achieve at least R9 status as it is believed that if you can stand on a ramp at between 3-10° and maintain secure footing then it must be acceptable when flat.

Wet areas and swimming pools

The DIN 51097 standard is used to assess the slip resistance of floor tiles under wet barefoot conditions. DIN 51097 is the only standard which classifies tiles for areas where people walk barefoot, e.g. around swimming pools, in changing rooms, showers and so on, where slip resistance is a higher priority. It too, uses ramp measurements and divides wet areas into 3 categories, indicating their suitability for specific applications.

Classification	Typical applications	Critical angle
Class A	Barefoot, but mainly dry aisles and walkways, dry changing areas	≥ 12°
Class B	Shower rooms, pool surrounds, wet changing areas disinfectant spray areas (plus all areas covered by Class A)	≥ 18°
Class C	Areas constantly under water, e.g. steps into pools, foot baths, inclined pool surrounds, jacuzzis (plus all areas covered by Class A and B)	≥ 24°

The opposite table shows work areas and environments with slippery surfaces and the R value that is recommended.

0 General work room and areas		10 Cold stores, deep freeze stores		19 Cast concrete factories	
Entrance areas	R9	For unpacked goods	R12	Concrete washing areas	R11
Stairs	R9	For packed goods	R11		
Social facilities (e.g. toilets, wash rooms)	R10			20 Storage areas	
Sanitary/medical treatment rooms	R9	11 Sales outlets, shops		Storage areas for oils and fats	R12
1 Manufacture of margarine, edible fats and oils		Reception of goods, meat	R11		
Melting of fat, cooking oil refinery	R13	Reception of goods, fish	R11	21 Chemical and thermal treatment of metal	
Margarine production		Serving counters for meat and sausage, unpacked	R11	Pickling plants	R12
and packaging, oil bottling	R12	Serving counters for meat and sausage, packed	R10	Hardening shops	R12
		Serving counters for fish	R12	Laboratory rooms	R11
2 Milk processing, cheese production		Meat preparation rooms	R12		
Fresh milk processing and butter production, ice cream manufacturing	R12	Florists shops	R11	22 Metal processing, metal shops	
Cheese production, storage and packaging	R11	Cash register areas, packing areas	R9	Galvanising shops	R12
		Serving counters for bread, cakes and pastries, unpacked goods	R10	Grey cast iron processing	R11
3 Chocolate and confectionery production				Mechanical processing areas (turnery, milling shop, etc.), punching room, pressroom, drawing shop (pies, wires) and areas exposed to increased stress by oil and lubricants	R11
Sugar and cocoa processing	R12	12 Health service rooms		Parts cleaning areas, exhaust steam areas	R12
Production of raw mixtures	R11	Disinfection rooms (wet)	R11		
Fabrication of chocolate bars and shells and filled chocolates	R11	Pathological facilities	R10	23 Vehicle repair workshops	
		Rooms for medical baths, hydrotherapy	R11	Repair and servicing bays	R11
4 Production of bread, cakes and pastries (bakeries, cake shops, production of long-life bakery products)		Washrooms of operating theatres	R10	Working and inspection pits	R12
Dough preparation	R11	Sanitary rooms, ward bathrooms	R10	Car washing halls	R11
Room in which predominately fats or liquid mixtures are processed	R12	Rooms for medical diagnosis and therapy, massage rooms	R9		
Washing-up rooms	R12	Operating theatres	R9	24 Aircraft repair workshops	
		Wards with hospital rooms and corridors	R9	Aircraft hangars	R11
5 Slaughtering, meat processing		Medical practices, day clinics	R9	Repair hangars	R12
Slaughter-house	R13	Pharmacies	R9	Washing halls	R12
Smoking establishments	R12	Laboratories	R9		
Salting and curing rooms	R12	13 Laundry		25 Sewage treatment plants	
Poultry processing	R12	Rooms with washing machines for washing of linen and clothes	R11	Pump rooms	R12
Cold cuts and packaging unit	R12	Ironing rooms	R9	Rooms for sludge draining facilities	R12
				Rooms for screening equipment	R12
6 Fish processing, production of delicatessen		14 Fodder concentrate production			
Fish processing	R13	Dried fodder production	R11	26 Fire brigade buildings	
Production of delicatessen	R13	Fodder concentrate production using fat and water	R11	Vehicle parking places	R12
Manufacture of mayonnaise	R13			Rooms for hose maintenance equipment	R12
		15 Leather production, textiles			
7 Processing of vegetables		Wet areas in tanneries	R13	27 Financial institutions	
Vegetable tinning	R13	Rooms with fleshing machines	R13	Counter areas	R9
Sterilising rooms	R11	Areas where leather scraps accumulate	R13		
Rooms in which vegetables are prepared for processing	R12	Rooms for making leather impermeable by means of grease	R12	28 Garages	
		Dye mills for textiles	R11	Garages, car-parks	R10
8 Wet areas in food and beverage production (if not specifically mentioned)					
Storage cellars	R10	16 Paint shops		29 Schools and kindergartens	
Beverage bottling, fruit juice production	R11	Wet grinding areas	R12	Entrance areas, corridors, assembly halls	R9
				Classrooms, group rooms	R9
9 Catering establishments		17 Ceramics industry		Stairs	R9
Restaurant and hotel kitchens: up to 100 meals per day	R11	Wet grinding mills (processing of ceramic raw materials)	R11	Toilets, washrooms	R10
more than 100 meals per day	R12	Mixers: handling of materials like tar, pitch, graphite and synthetic resins	R11	Instructional kitchens in schools (also see no.9)	R10
Kitchens catering for homes, schools kindergartens, sanatoria	R11	Presses (shaping); handling of materials	R11	Kitchens in kindergartens (also see no.9)	R10
Kitchens catering for hospitals, clinics	R12	Moulding and glazing areas	R12	Special rooms for handicrafts	R10
Large kitchens catering for industrial and university canteens, and contract catering	R12				
Food preparation kitchens (fast food kitchens, snack bars)	R12	18 Glass and stone processing		1 Outdoor areas	
Washing up rooms	R12	Stone cutting, stone grinding	R11	Entrance areas and stairs	R11 or R10
Dining rooms, guest rooms, canteens including serving counters	R9	Glass shaping, etching and acid polishing facilities for glass	R11	Traffic routes	R11 or R10
				Loading platforms, covered	R11 or R10
				Loading platforms, not covered	R12
				Sloping ramps (e.g. for wheel-chairs, loading platforms)	R12
				2 Parking areas	
				Open air parking areas	R11 or R10



Which test is best?

The ISO for ceramic tiles (ISO 10545) establishes international definitions for the characteristics, testing methods, classification criteria and labelling of ceramic tiles. It includes sections on the co-efficient of restitution, Mohs hardness, and the modulus of rupture. However, interested parties from a number of European countries have continually failed to agree on one single preferred test for anti-slip, citing the following:

- The ASTM test is unscientific.
- The Tortus test can give misleading results in wet conditions compared to dry.
- The Pendulum test favours non-profiled flooring.
- The Ramp test cannot be conducted under site conditions.

Porcelanosa's test methods

Porcelanosa utilise the Ramp test and the TRRL Pendulum test for tile ranges whose final use must comply with the requirements of non-slip floors. Controls are performed on the basis of samples taken from each production run of a 'model'.

Test results are given in the table opposite. Ramp test R values are also shown on product data pages (in Sections 2, 3 and 4).

Test results for anti-slip properties (various test methods)

Figures quoted are based on average results taken from the smallest tile in each range.
Test certificates are available for each tile range from Porcelanosa on request.

Tile range	Ramp test (R-value) to DIN 51330	Determination of slip resistance with barefeet on wet area to DIN 51097	TRRL Pendulum Test – Wet	TRRL Pendulum Test – Dry	Tortus Test – Wet	Tortus Test – Dry	Product sheet reference
Silver	R9	A	–	–	Satisfactory	Satisfactory	2.1.2
Durango	R10	A	–	–	Satisfactory	Satisfactory	2.1.3
Durango Antislip	R12	C	49	60	Excellent	Excellent	2.1.3
Piacentina	R10	A	–	–	Satisfactory	Excellent	2.1.4
Piacentina Antislip	R11	A	40	56	Satisfactory	Excellent	2.1.4
Shanghai	R9	A	–	–	Satisfactory	Satisfactory	2.1.5
Kenya	R9	A	–	–	Satisfactory	Satisfactory	2.1.6
Kenya Antislip	R10	A	53	63	Excellent	Excellent	2.1.6
Osaka	R9	A	–	–	Satisfactory	Satisfactory	2.1.7
Osaka Antislip	R10	A	46	57	Excellent	Excellent	2.1.7
Ulldecona	R9	A	–	–	Satisfactory	Satisfactory	2.1.8
Ulldecona Antislip	R10	C	52	63	Satisfactory	Satisfactory	2.1.8
Mino	R9	A	–	–	Satisfactory	Satisfactory	2.1.9
Mino Antislip	R10	A	45	58	Excellent	Excellent	2.1.9
Alpina	R10	A	23	49	Satisfactory	Satisfactory	2.1.10
Assur	R9	A	22	47	Satisfactory	Excellent	2.1.11
Carpatia	R10	A	28	51	Satisfactory	Satisfactory	2.1.12
Carpatia Antislip	R12	C	49	61	Excellent	Excellent	2.1.12
Caucaso	R9	A	23	49	Satisfactory	Satisfactory	2.1.14
Caucaso Antislip	R12	C	49	60	Excellent	Excellent	2.1.14
Pedralbes	R9	A	22	47	Satisfactory	Excellent	2.1.16
Via Emilia	R10	A	29	52	Satisfactory	Satisfactory	2.1.17
Via Emilia Antislip	R12	C	51	59	Excellent	Excellent	2.1.17
Yuste	R10	A	30	52	Satisfactory	Excellent	2.1.18
Yuste Antislip	R12	C	48	60	Satisfactory	Excellent	2.1.18
Altamira	R10	A	28	51	Satisfactory	Excellent	2.1.19
Altamira Antislip	R12	C	50	61	Excellent	Excellent	2.1.19

Cleaning and maintenance

The specifier should also consider how the installed tiles are to be cleaned and maintained once installed. This is a crucial aspect of specifying anti-slip tiles. It is no good specifying the correct tiles in accordance with any of the aforementioned test methods, if a proper cleaning regime is not in place, and therefore the tiles fail to perform after a short period.

Whilst looking similar in surface appearance, some tiles actually appear very different under a microscope. Just because a tile is designated as having an anti-slip finish, this is not the only consideration. When we take a shower, for example, we may use various lotions and potions, and along with body fats these can clog the surface micropores, which in time will reduce the tile's anti-slip properties.

Site problems often occur quite quickly after installation. This can be due to an almost invisible layer of grout remaining in the micropores of the tile. Correct specification of cleaning agents at the NBS M40 stage can help avoid this.

Similarly, the use of incorrect cleaning agents (i.e. soap based detergents) can also have a detrimental effect, even if they appear to be keeping the floor clean.

Refer to section 6.2 in this binder, on 'Cleaning and maintenance, for further information.

PORCELANOSA®

Porcelanosa Group Limited www.porcelanosa.co.uk

t: 08702 240245 f: 08702 240246 e: group@porcelanosa.co.uk